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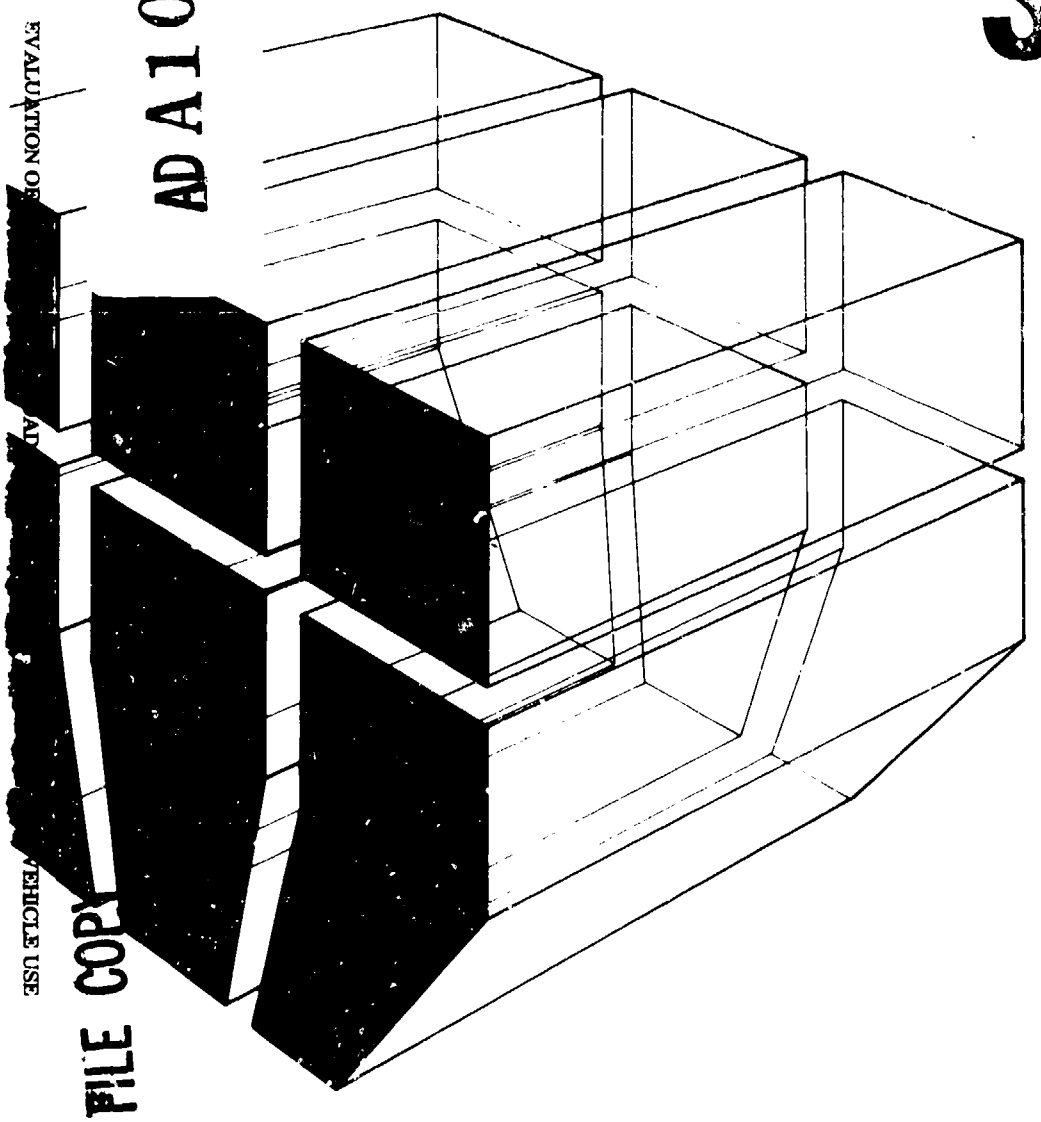
TECHNICAL REPORT N-110
Guidelines for Natural Resources Management and Land Use Compatability
October 1981

EVALUATION OF LANDS FOR OFF-ROAD RECREATIONAL FOUR-WHEEL DRIVE VEHICLE USE



by
R. M. Lacey
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TECHNICAL REPORT N-110

EVALUATION OF LANDS FOR OFF-ROAD RECREATIONAL FOUR-WHEEL DRIVE VEHICLE USE

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This report describes a method to evaluate land areas on Army installations for use by off-road recreational four-wheel drive (4WD) vehicles. The method describes how to identify incompatible land uses and noise conflict, choose candidate areas, evaluate soil and biological suitability, and develop trails. Also discussed are 4WD user participation, trail design, vehicle operating conditions, and environmental assessment and monitoring.

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The information in this report focuses on the purely recreational use of 4WD vehicles. The evaluation method is designed to be as nontechnical as possible, so Army personnel normally charged with installation land management can perform the evaluation. The method can also be used for many public and private applications.

FOREWORD

This investigation was performed for the Directorate of Military Programs, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities;" Task B, "Land Use Planning"; Work Unit 024, "Guidelines for Natural Resources Management and Land Use Compatibility." The applicable QCR is 3.01.001. The OCE Technical Monitor was Mr. Donald Bandel, DAEN-MPO-B.

The work was performed by the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (CERL). The assistance of the following CERL personnel is specifically acknowledged: Dr. Harold Balbach, Mr. Robert Baran, Mr. David Hunt, Dr. Richard Raspet, and Dr. Paul Schomer. Dr. R. K. Jain is Chief of EN.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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EVALUATION OF LANDS FOR OFF-ROAD RECREATIONAL FOUR-WHEEL DRIVE VEHICLE USE

1 INTRODUCTION

Background

Presidential Executive Orders 11644 and 11989 require that public lands in the custody of the Federal Government be evaluated for potential use by off-road recreational vehicles (ORRVs).[1] Army Regulation (AR) 210-9 establishes uniform policies, procedures, and criteria for controlling off-road travel by ORRVs on Army installations and prescribes appropriate operating conditions for such vehicles.[2] The Presidential Orders and the AR were issued as a result of increasingly widespread use of ORRVs on public lands -- use which was recognized as being frequently in conflict with wise land and resource management practices. The goal of these regulatory mandates is to allow persons to enjoy ORRV-use opportunities while considering the long-term stability of environmental resources.

To help Army installation personnel comply with these mandates, the U.S. Army Construction Engineering Research Laboratory (CERL) has developed a method to evaluate land areas for ORRV use. ORRVs include trailbikes, snowmobiles, four-wheel drive (4WD) vehicles and trucks, dune buggies, all-terrain vehicles, swamp buggies, etc. These types of ORRVs are designed to be used for different purposes and to travel across different surfaces; therefore, the method to evaluate land areas is quite flexible and includes different considerations for different types of vehicles. This report describes how CERL's method can be used to evaluate lands for recreational 4WD use. Guidance on how to use the method to evaluate areas for recreational trailbike and snowmobile use has been issued in Engineer Technical Note (ETN) 80-9 and CERL Technical Reports N-86 and N-105.[3]

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[1] Executive Order No. 11644, "Use of Off-Road Vehicles on the Public Lands," Federal Register, Vol 37, No. 27 (8 February 1972), pp 2877-2878; and Executive Order No. 11989, "Off-Road Vehicles on Public Land," Federal Register, Vol 42, No. 101 (24 May 1977), pp 26959-26960.

[2] Installations -- Use of Off-Road Vehicles on Army Land, Army Regulation (AR) 210-9 (Headquarters [HQ], Department of the Army [DA], 1 July 1978).

[3] Evaluation of Areas for Off-Road Recreational Motorcycle Use, Engineer Technical Note (ETN) 80-9 (DA, Office of the Chief of Engineers [OCE], 4 March 1980); R. M. Lacey, H. E. Balbach, R. S. Baran, and R. G. Graff. Evaluation of Areas for Off-Road Recreational Motorcycle Use, Volume I: Evaluation Method, and R. M. Lacey and H. E. Balbach, Volume II: Alternate Soil Suitability Determination Methods, Technical Report N-86/ADA096528 and ADA096529 (U.S. Army Construction Engineering Research Laboratory [CERL] November 1980); and R. M. Lacey, R. S. Baran, W. D. Severinghaus, and D. J. Hunt, Evaluation of Lands for Recreational Snowmobile Use, Technical Report N-105 (CERL, May 1981).

Purpose

The purpose of this report is to describe how to evaluate lands for off-road recreational 4WD vehicle use.

Approach

Much of the information used to develop the ORRV evaluation method was obtained from three sources:

1. A literature search identified available, published material on ORRVs -- particularly material on ORRV user characteristics, environmental impact, and trail development.

2. Federal and State land and recreation program managers were contacted to obtain available information on existing ORRV programs.

3. Industry representatives and user groups -- including the United Four-Wheel Drive Associations -- were contacted for information on vehicle characteristics and user attitudes and preferences.

From this information, appropriate criteria for ORRV use on installation lands were identified and a systematic evaluation method designed. Aspects of vehicle use for various ORRVs were then identified. Procedures involved in the evaluation method were then field-tested for trailbike and snowmobile use. Results of this test were used to improve the evaluation method; factors which can be used to evaluate 4WD vehicle use were then incorporated into the method.

Scope

The method described in this report focuses on the purely recreational use of 4WD vehicles. Competitive events are not considered, nor does the category of 4WD vehicles considered include dune buggy-type, amphibious, homemade, or significantly modified factory-built vehicles. The vehicles considered include small 4WD vehicles (e.g. Jeeps, Broncos, Scouts) which are usually registered as passenger cars, and 4WD pickups which may be registered as light trucks.

Mode of Technology Transfer

The method and information described in this report is not anticipated to impact any current Army guidance documents. An ETN describing the availability of this and other reports related to ORRV planning will be distributed to field personnel.

2 HOW TO EXAMINE EXISTING LAND USE

Overview of the Evaluation Method

The evaluation method described in this report deals primarily with the environmental factors considered in AR 210-9. Other factors, such as citizen participation, determination of demand, trail design, and operating conditions are included, but they are not discussed in depth. The method is designed for use by persons in Army installation natural resource, environmental, and master planning offices. Use of the method should be coordinated with all appropriate offices having responsibilities under the authority of AR 28-1, AR 190-5, AR 190-5-1, AR 200-2, AR 210-20, AR 405-80, and AR 420-74.[4]

Figure 1 is a flow diagram of the steps involved in the evaluation method. These steps are briefly described below. Procedures necessary to complete the steps are given in the following chapters and in the appendices.

Examine Existing Land Use

The method begins by eliminating from consideration all incompatible land uses.

Identify Noise Conflict

Conflict with noise-sensitive land uses is identified and noise buffer zones or use limits are established, depending on available acreage.

Choose Candidate Areas

Potential candidate areas are chosen from the remaining land area.

Evaluate Soil Suitability

Soils of candidate areas are rated as having slight, moderate, or severe limitations for recreational 4WD use.

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[4] Welfare, Recreation, and Morale -- Army Morale Support Activities, AR 28-1 (HQ, DA, 15 February 1979); Military Police -- Motor Vehicle Traffic Supervision, AR 190-5 (Departments of the Army, Navy, Air Force, and the Defense Supply Agency, 1 August 1973); Military Police -- Registration of Privately-Owned Motor Vehicles, AR 190-5-1 (HQ, DA, 15 July 1978); Environmental Protection and Enhancement, AR 200-2, Federal Register, Vol 45, No. 3 (4 January 1980), pp 1086-1108; Master Planning for Army Installations, AR 210-20 (HQ, DA, 26 January 1976); Real Estate -- Granting Use of Real Estate, AR 405-80 (HQ, DA, 1 February 1979); and Natural Resources -- Land, Forest, and Wildlife Management, AR 420-74 (HQ, DA, 1 July 1977).

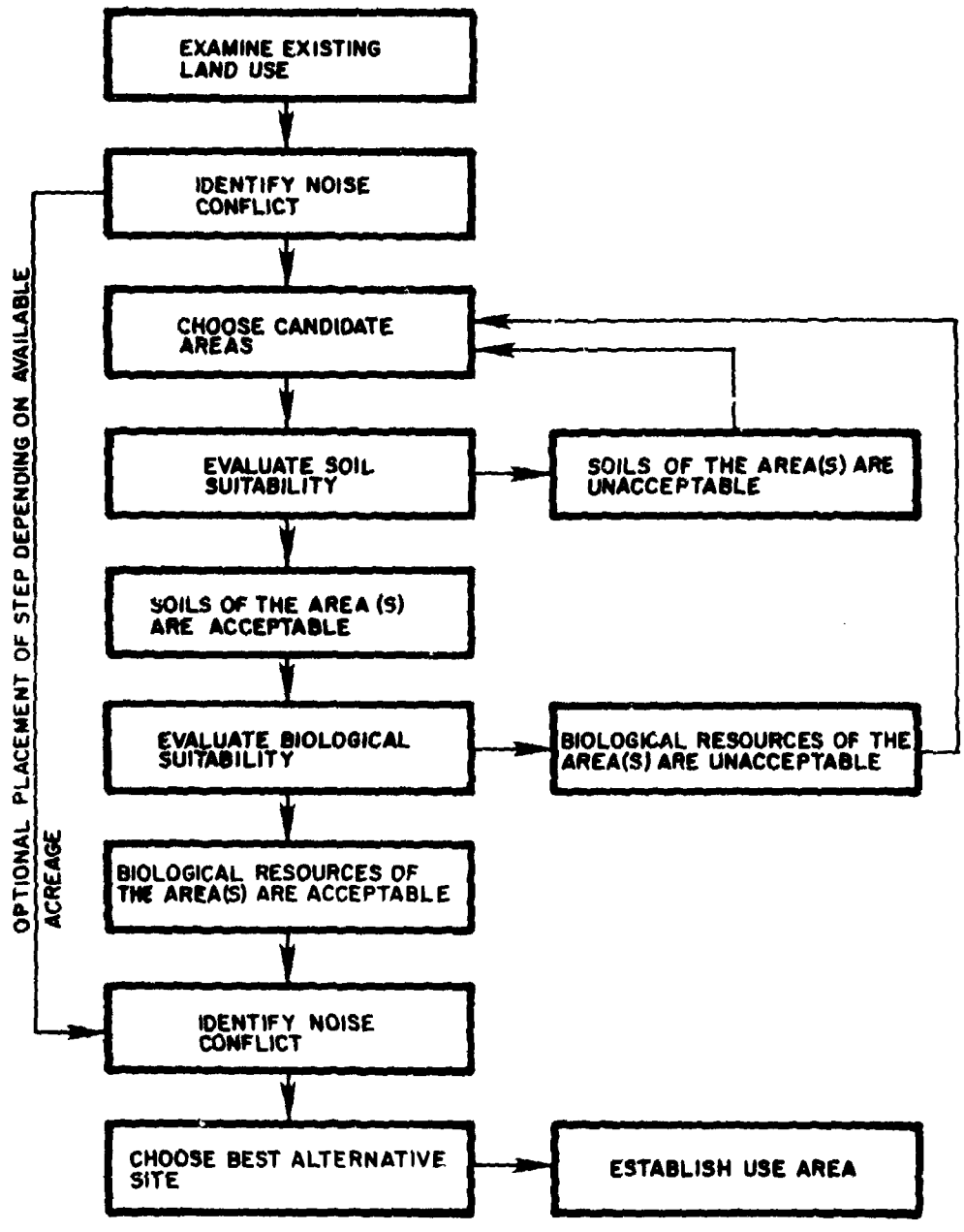

Figure 1. Steps in 4WD vehicle evaluation method.

Evaluate Biological Suitability

The candidate areas are surveyed to determine the value or susceptibility to damage of biological resources. The presence of significant plant and animal species, critical habitat, etc., is considered.

Choose Best Site and Establish Use Area

Acceptable areas or trails may be designated as open to 4WD vehicles, provided that the other nonenvironmental policies and criteria established by AR 210-9 can be met. Before designating areas or trails as open to ORRV use, an environmental assessment should be done.

Input

Lands under Army control were acquired solely for national defense purposes; other uses are secondary to mission needs. Therefore, the evaluation method begins by eliminating from consideration those lands, among others, which are necessary to meet mission requirements.

Major sources of incompatible land use information include the Installation Master Plan, Land Management Plan, Endangered Species Inventory, Historic/Archaeologic Resources Management Program, and the Office of the Director of Plans and Training. These sources are not exclusive. Any source which can be used to identify the location of potentially incompatible, sensitive, fragile, and unique land uses or areas should be consulted.

Criteria for Incompatible Land Uses

After all available sources of information have been studied, certain parts of an installation must be eliminated from consideration as areas for 4WD vehicle use. Incompatible land use categories are based on the principles and examples in AR 210-9 or are land uses generally known to conflict with ORRV use. AR 210-9 generally describes several categories of lands which are to be specifically declared unavailable for ORRV use. Briefly, these are:

1. Areas where the mission, security, and operation of the installation would be adversely affected by ORRV use, i.e., explosive ordnance storage, impact areas, and drop zones.

2. Areas which cannot be used because of existing land use, i.e., agricultural outleases and noise-sensitive outdoor recreation areas.

3. Areas where the operation of 4WD vehicles would be unsafe for participants and nonparticipants, i.e., abandoned ordnance impact areas and trails set aside for other uses such as hiking or horseback riding.

4. Areas which have been identified as, or are suspected to be, historically/archaeologically significant, critical wildlife habitat, critical natural resource areas, etc.

Table 1 lists several examples of land uses which are or may be incompatible with 4WD vehicle use. It also gives conditions or conflicts, either existing or created by 4WD use, which should be considered when examining suspect land uses for possible classification into any of the above categories. Table 1 is not all-inclusive, and any land use which uniformly exhibits or could be affected by one or more of the conflict conditions should be eliminated from consideration as a 4WD vehicle-use area.

Special Considerations

Most recreational 4WD vehicles can be used throughout the year -- summer and winter. Therefore, some special seasonal conditions apply for determining incompatible land uses and areas. These special considerations relate to wildlife and vegetation. Qualified biologists and foresters should be consulted for recommendations pertaining to these considerations.

Wildlife

During the harsh, northern winter months, wildlife may be weakened by a reduction in available food. This condition can result in death from exhaustion or exposure, if animal activity is increased because of the presence of man and machine. The wintering condition of resident animals in candidate areas should be examined before an area or trail is opened to winter use. Special attention should be given to identifying -- and eliminating from consideration for trail development -- areas where wildlife concentrate and feed during winter months, e.g., deer yards.

Vegetation

When 4WD vehicles run over plants or compact the snow too firmly, the early spring growth of vegetation may be adversely affected. As a result, special consideration should be given to prohibiting 4WD operation where predominant vegetation is being managed for commercial or other use -- e.g., winter wheat or alfalfa fields, timber plantations, and grassland preserves.

Mapping of Incompatible Land Uses

Once all incompatible land uses and areas have been identified, they should be marked on an installation map. (See Figure 2 for a simplified example.) Generally, a Reservation Plan or Master Plan map is most suitable for this identification, since it will reflect other future land uses. This map is then used as a working base map for other parts of the evaluation method.

Table 1

Land Uses and Areas Which Are Incompatible With
Four-Wheel Drive Vehicle Use

Examples of Land Uses Which Conflict With Four-Wheel Drive Vehicle Use (By Category of Conflict)	Conditions Which Place Land Uses in Conflict
Safety and Security of Military Function	
Land Uses	**Conflict Conditions**
o Active bivouac areas	o Live fire
o Active non-mechanized training areas	o National security
o Airfield aprons & approach zones	o Personal safety of Army personnel
o Demolition areas	o Physical security of personal property
o Explosives storage	o Quantity-distance limits
o Impact areas	o Unexploded ordnance
o Motor pools	o Tactical vehicle operations
Incompatible Land Uses	
Land Uses	**Conflict Conditions**
o Administrative areas	o Aesthetics
o Agriculture/grazing outleases	o Dust
o Campgrounds	o Encroachment
o Churches	o Noise
o Family housing	o Personal safety of personnel
o Hospitals	o Property security
o Industrial sites	o Traffic congestion
o Libraries	o Vandalism
o Outdoor theaters	o Vehicle operation
o Schools (military and dependent)	
o Troop housing	
Participant & Nonparticipant Safety	
Land Uses	**Conflict Conditions**
o Active landfills	o Live fire
o Active quarries & mines	o Loose surface material
o Active training areas	o Moving tactical vehicles
o Demolition areas	o Noise
o Explosive storage	o Personal safety
o Frozen water bodies	o Recreational conflict

Table 1 (Cont'd)

Examples of Land Uses Which Conflict With Four-Wheel Drive Vehicle Use (By Category of Conflict)	Conditions Which Place Land Uses in Conflict
Participant & Nonparticipant Safety (cont'd)	
o Hiking trails	o Steep slopes
o Horse (bridle) trails	o Thin ice
o Impact areas	o Unexpected animal actions
o Passive outdoor recreation	o Unexploded ordnance
o Potable water storage	o Water quality
o Ranges	
o Hunting areas	
Natural and Other Resource Locations	
Land Uses	**Conflict Conditions**
o Archaeological sites	o Aesthetics
o Breeding, migration, or nesting areas	o Animal harassment
o Cemeteries	o Dust
o Food plots and feeding areas	o Encroachment
o Historic sites and structures	o Human presence and disruption
o Paleontologic sites	o Noise
o Petroglyphs	o Poaching
o Rare, endangered, or threatened plants, animals, and fish	o Petroleum spills
o Wetlands	o Siltation
	o Soil compaction
	o Soil erosion
	o Turbidity
	o Vandalism
	o Vegetation damage

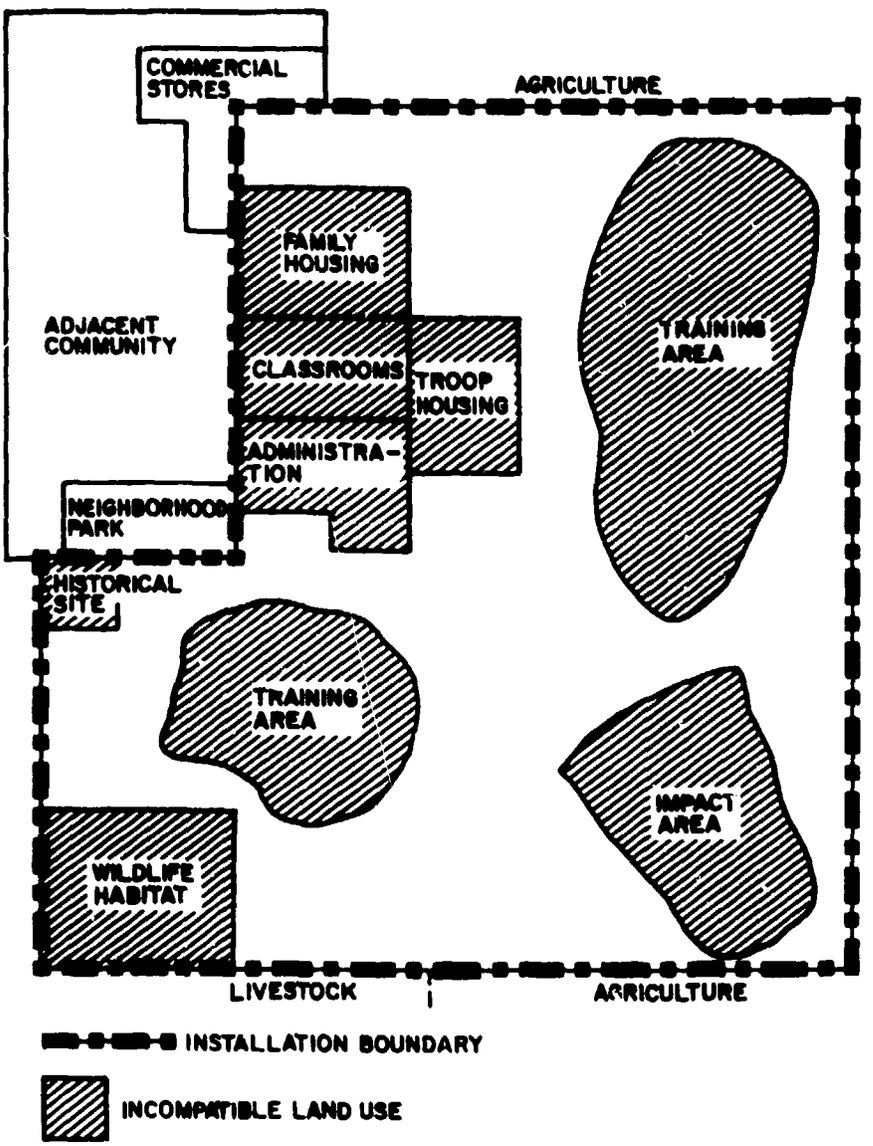

Figure 2. Base map identification of incompatible land use.

3 HOW TO IDENTIFY NOISE CONFLICT

Input

To identify noise conflict, noise-sensitive land uses on and adjacent to the installation must be identified. The number of 4WD vehicles expected to use an area or trail and their average noise level must also be estimated.

Noise-Sensitive Land Uses

Many land uses are sensitive to excessive noise levels. For example, a hospital or nursing home would be "sensitive" to a nearby 4WD vehicle-use area. Table 2 lists maximum acceptable equivalent sound-level (Leq) requirements for various noise-sensitive areas.* The table was adapted from Figure 4-5 of Army Technical Manual (TM) 5-803-2.[5] The sound levels in TM 5-803-2 assume that a new facility is to be constructed in an existing noise environment, while Table 2 assumes that a new noise-generating land use is being developed adjacent to an existing facility or land use. Therefore, some modification in the sound-level requirements was necessary.

Each land use identified in Table 2 is considered noise-sensitive and has a value indicating a maximum acceptable sound-level requirement. If any of these land uses exists on or adjacent to an installation boundary, they should be identified on the base map (p 17). Because Table 2 does not list all noise-sensitive land uses, any land use suspected to be noise-sensitive should be included in that category which seems appropriate. Good judgment is essential in this determination.

Projected Demand

Projected demand is defined as the average daily use expected for a proposed use area. To compute the average daily use, the maximum number of 4WD vehicles which will be in operation in a proposed area is estimated for each day of the week; these estimates are then added and divided by seven. To insure that noise level requirements are not exceeded, estimated use should be based on demand during weeks when use is expected to be the highest. Daily use estimates should be generous enough to accommodate any unexpected increase in demand.

A quantitative procedure for estimating peak use is not included in this report, since little information is currently available for projecting such demand. However, AR 210-9 specifically recognizes the need for user participation in the site selection and development of ORRV-use areas. AR 210-9 also states that organized recreational activities involving ORRVs are within the scope of the Outdoor Recreation Program of the Army Recreation Services. Therefore, the best sources for determining local demand are users and persons

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* The Leq is the steady level, in A-weighted decibels, that would produce the same A-weighted sound energy over a given time period as a time-varying sound.

5 Environmental Protection: Planning in the Noise Environment, Technical Manual (TM) 5-803-2 (Departments of the Air Force, Army, and Navy, 15 June 1978).

Table 2

Leq Requirements for Selected Land Uses

(Adapted from TM 5-803-2, Figure 4-5, Environmental Protection Planning in the Noise Environment [Departments of the Air Force, Army, and Navy, 15 June 1978].)

Land Use	Maximum Acceptable Sound Level (in dBA)
Agricultural (except livestock)	80
Bachelor housing	65
Campgrounds and picnic areas (not associated with ORRV's)	65
Classrooms, libraries, and churches	65
Commercial and retail stores, exchanges, movie theaters, restaurants and cafeterias, banks, credit unions, enlisted officers' clubs	70
Dental clinic, medical dispensaries	70
Family housing	65
Flight line operations, maintenance, and training	80
Gymnasiums, indoor pools	70
Hospitals, medical facilities, Nursing homes (24-hour occupancy)	65
Industrial, manufacturing, and laboratories	70
Livestock farming, animal breeding	75

Table 2 (Cont'd)

Land Use	Maximum Acceptable Sound Level (in dBA)
Neighborhood parks	70
Offices and administration buildings -- military	70
Offices -- business and professional	70
Outdoor music shells, outdoor theaters, and cultural events	65
Outdoor sports arenas, outdoor spectator sports	70
Playgrounds, active sport recreational areas	70
Transient lodging -- hotel, motel, etc.	65
Troop housing	65

from the installation's outdoor recreation staff -- specifically, individuals who know how to project recreation demand or who may have received requests from users. Assistance from representatives of the National Park Service of the U.S. Department of the Interior or appropriate State agencies should also be of value.

Noise Levels

Noise levels generated by 4WD vehicles vary, depending on (1) the type of vehicle, (2) whether (and how) the user has modified the vehicle, (3) the mode of operation, and (4) vehicle speed during operation.

Noise Measurements. The most accurate way to estimate noise levels is to take noise measurements of a representative sample of vehicles. On many installations, the Preventive Medicine Office, Environmental Office, or Provost Marshal may be able to supply equipment which can be used to measure 4WD vehicle noise levels. Users and recreation staffs can be consulted to determine the types of vehicles which will probably be used in the ORRV area. Generally, users will help Army personnel measure the sound levels of their vehicles. Measurements should be taken in conditions which would simulate actual recreational use. The level used to identify noise conflict should be the average noise level, in A-weighted decibels (dBA), at 15.24 m during actual vehicle operation.

Noise Estimates. If the average sound levels generated by 4WD vehicles cannot be measured, noise estimates may be used. Noise levels generated by 4WD vehicles can be considered comparable to those generated by automobiles and light trucks. Data on the noise levels generated by road movement of these types of vehicles are considerable. However, data on off-road movement are fairly limited. Off-road noise levels can be affected by a variety of factors, e.g., slope and ground cover. The best off-road estimates identified during research for this report range from 72 to 83 dBA for most light trucks and all-terrain vehicles.[6] If noise levels for a representative sample of vehicles cannot be measured, the following estimates are recommended:

1. 76 dBA at 15.24 m for the average noise level, if most vehicles expected to use the area or trail appear to have nondefective or unmodified muffler systems.

2. 80 dBA at 15.24 m for the average noise level, if most vehicles expected to use the area or trail appear to have defective or modified muffler systems.

3. Unlicensed or unmuffled vehicles must not be allowed to operate in the area or along the trail.

[6] Robin T. Harrison, Roger N. Clark, and George H. Stankey, Predicting the Impact of Noise on Recreationists: An Application of the Outdoor Recreation Opportunity Spectrum (U.S. Department of Agriculture, Forest Service, 1980).

Distance Necessary for Noise Attenuation (DNNA)

Once projected demand and the measured or estimated noise levels of 4WD vehicles have been identified, the Distance Necessary for Noise Attenuation (DNNA) for each noise-sensitive land use can be computed. The DNNA is the distance a 4WD vehicle trail would have to be located away from a noise-sensitive land use to meet recommended maximum acceptable noise-level requirements. The following is an example of how to calculate the DNNA.*

Calculation or Description and Example

The DNNA can be determined by the following equation:

$$DNNA = A \times 10^{\left[\frac{B + 10(\log C) - (D - 5)^{**}}{20}\right]} \qquad \text{[Eq 1]}$$

where: DNNA = The Distance Necessary for Noise Attenuation

A = The distance (feet or meters) from which sound-level measurements were taken to determine the average noise level of 4WD vehicles which will use the area or trail

B = The average noise level (in dBA) of the 4WD vehicles which will use the area or trail

C = The estimated average daily use of the area or trail (projected demand); this demand is determined by projecting the number of vehicles which will use area or trail each day of the week, adding these numbers, and dividing by seven)

D = The Leq for land use for which a buffer zone is being established or for which adjacent limited use is necessary (Table 2).

*There are several ways to determine the DNNA for ORRV use. The technique provided in this report was chosen for its simplicity. However, it yields very conservative results. If more detailed measures of DNNA are desired, the user may wish to use other techniques. Two excellent sources are: (1) Environmental Protection: Planning in the Noise Environment, TM 5-803-2 (Departments of the Air Force, Army, and Navy, 15 June 1978), and (2) Robin T. Harrison, Roger N. Clark, and George H. Stankey, Predicting the Impact of Noise on Recreationists: An Application of the Outdoor Recreation Opportunity Spectrum (U.S. Department of Agriculture, Forest Service, 1980).

**The term "D-5" in the argument of Eq 1 represents an 5-dB penalty in the Leq for land uses. This penalty is included as a precaution, because the sound of 4WD vehicles can be intrusive and annoying if their muffling systems are modified.

For example, assume that the projected demand for a potential 4WD vehicle trail is an average daily use of 10 vehicles and that each vehicle generates an average of 76 dBA at 15.24 m. Further assume that a noise buffer zone must be established around a family housing area. From Table 2, it is known that the Leq for family housing is 65 dBA. Therefore:

A = 15.24 m
B = 76 dBA
C = 10 4WD vehicles
D = 65 dBA for family housing

and:

$$DNNA = 15.24 \times 10^{\left[\frac{76 + 10(\log 10) - (65 - 5)}{20}\right]}$$

$$DNNA = 15.24 \times 10^{\left[\frac{76 + 10(1) - 60}{20}\right]}$$

$$DNNA = 15.24 \times 10^{\left[\frac{76 + 10 - 60}{20}\right]}$$

$$DNNA = 15.24 \times 10^{\left[\frac{26}{20}\right]}$$

$$DNNA = 15.24 \times 10^{(1.3)}$$

$$DNNA = 15.24 \times 19.95$$

$$DNNA = 304 \text{ m}$$

Based on this DNNA calculation, a noise buffer zone of at least 304 m should be established around the family housing area. In other words, any trail with a projected average daily demand of 10 4WD vehicles, each generating an average of 76 dBA, should be located no closer than 304 m from family housing.

Precalculated DNNAs

For the user's convenience, a set of precalculated DNNAs for various Leqs, projected use parameters, and noise levels are given in Table A1 in Appendix A. All distances in the table were calculated using Eq 1.

Establishing Noise Buffer Zones

Once the DNNAs for each noise-sensitive land use are identified, they must be marked on the base map (see p 17). To do this, lines are drawn around each noise-sensitive land use at that distance (corresponding to the scale of the map) which illustrates the minimum distance outside which a 4WD vehicle trail could be located (see Figure 3 for a simplified example). The areas between these lines and the noise-sensitive land uses are the noise buffer zones. The acreage in these zones, as well as the acreage in the noise-sensitive land use, should be eliminated from consideration for use by recreational 4WD vehicles. It is recommended that regardless of the DNNA calculation, noise buffer zones be at least 100 m.

Limited-Use Alternative

On many installations, there may be so much demand that the area required for noise buffer zones will eliminate nearly all available acreage. In these cases, it will be necessary, despite demand, to limit use at any established 4WD vehicle trail. The limited-use alternative for insuring that maximum acceptable sound levels are not exceeded requires altering the order in which the method's evaluation steps are completed (see Figure 1). This is done by choosing candidate areas (Chapter 4), evaluating soil suitability (Chapter 5), and examining biological and other environmental factors (Chapter 6) before using the noise equation or the table in Appendix A. If an environmentally acceptable area is identified, the distances that a candidate area's trails are from noise-sensitive land uses become known variables, and the number of 4WD vehicles which may be allowed to use the trails becomes the unknown factor. By using all known variables as input and solving Eq 1, the average daily number of vehicles which can reasonably use the trails is determined. If a 4WD vehicle area is established, this average number cannot be exceeded without unacceptable noise impacts on adjacent land uses.

For example, assume that the projected demand for a potential 4WD vehicle trail is an average daily use of 30 vehicles, each generating 76 dBA at 15.24 m. Further assume that the trail is located 304 m from family housing. Based on the previous description of the calculation for DNNA, if a trail is established along the potential route, the use must be limited to a daily average of 10 vehicles.

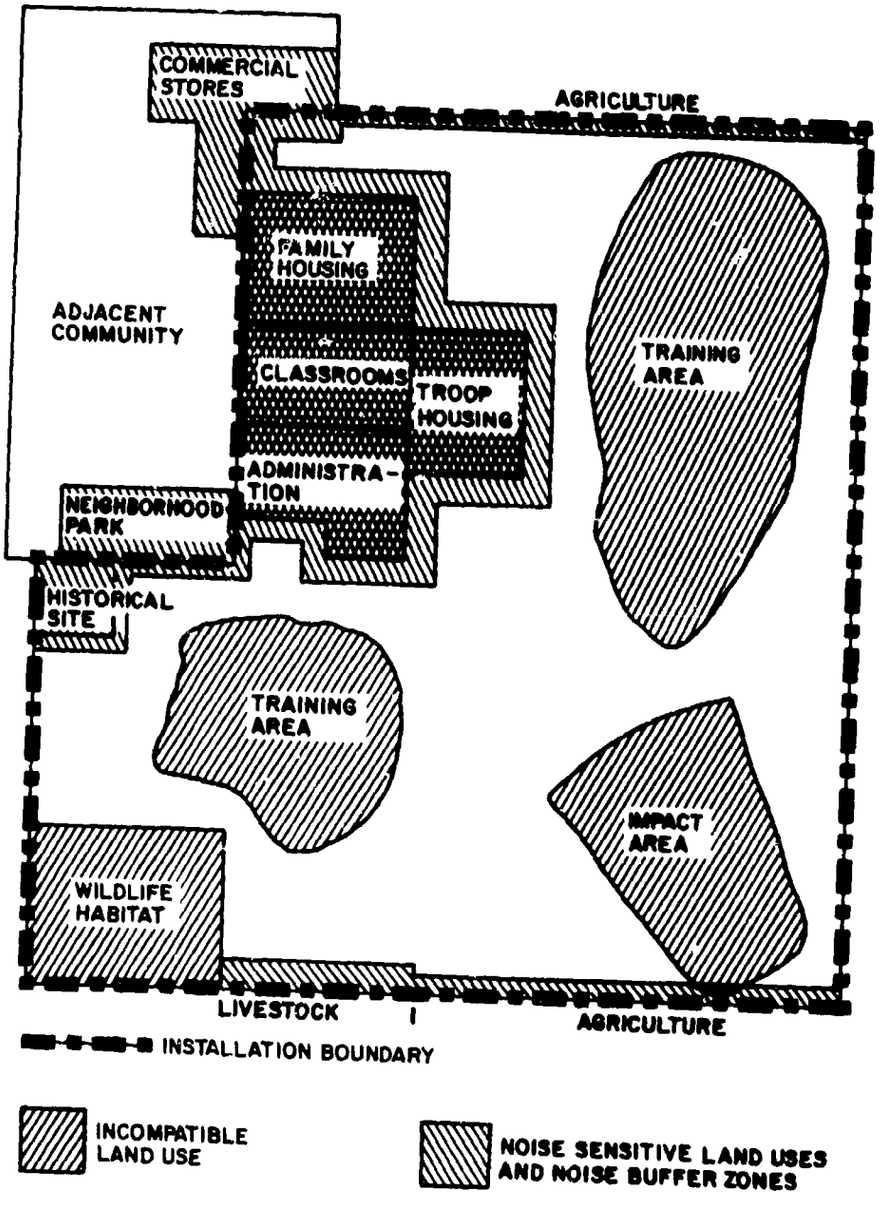

Figure 3. Noise-sensitive land uses and noise buffer zones.

4 HOW TO CHOOSE CANDIDATE AREAS

Input

The base map described in Chapters 2 and 3 is used to decide which areas or corridors on an installation may be suitable candidates for 4WD vehicle use and trail development. Topographic maps are also useful. Factors to consider include projected demand, user preferences, site accessibility, and terrain characteristics. To determine use and user characteristics, local user groups, both on and off the installation, should be consulted. Methods to obtain user input are discussed in Chapter 7. Natural resource personnel who have worked on an installation for some time can supply information about an installation's physical and environmental resources -- information which can be very useful in choosing candidate areas.

General Criteria

In addition to input from users and natural resource personnel, the following general criteria for candidate area selection should also be considered.

Acreage

Research indicates that areas now used by ORRVs range from 5 to 800 ha or greater, depending on the type of vehicle, intensity of user demand, type of terrain, available land area, and trail configuration. The length of trails can be quite variable, e.g., from about 3.2 to greater than 161 km. It is recommended that candidate 4WD vehicle areas for the average installation be no greater than 150 ha. This is estimated to be the maximum area which the average installation could devote to such use. This does not imply that the final use area will be this size. Further site evaluation may indicate that portions of candidate areas are unacceptable and the actual area available for use will be reduced. The exact size and shape of a specific candidate area will depend on available acreage and type of use. If trail rather than cross-country use is preferred by local users, then the areas chosen may actually be corridors.

Site Requirements

Candidate areas should be easy to reach by road to reduce cross-country travel to the site. If trail, rather than cross-country use is preferred, areas should be selected which already exhibit some form of existing trail system, e.g., fire breaks or an unpaved road system that could be closed to general traffic.

Terrain Characteristics

Users consider variety the most desirable terrain characteristic. This includes variety in trail alignment, trailside vegetation, and scenic views. However, certain terrain and vegetation characteristics will make areas generally unsuitable. Many of these unsuitable characteristics are described below and summarized in Figure 4.

When Evaluating Terrain Characteristics for Possible 4WD Vehicle Use, Areas May Be Considered Generally

UNSUITABLE IF:	SUITABLE IF:
1. The average degree of slope normally exceeds 30 to 35 percent.	1. The average degree of slope or maximum slope does not normally exceed 30 to 35 percent.
2. They are low-lying areas, e.g., seasonally wet bottomlands.	2. They are upland areas with few streams and water bodies.
3. They contain vegetation resources which are valuable and highly susceptible to damage.	3. They contain vegetation resources of average or lower value and low susceptibility to damage.
4. They will require considerable site preparation, e.g., clearing.	4. They will require a minimal amount of site preparation.
5. They have already been very severely damaged.	5. They have already been damaged, but not too severely.
6. They contain a considerable number of large boulders.	6. They have gravelly and/or stony surfaces.
7. The water table is generally at a depth of less than 1.2 m.	7. The water table is generally at a depth of greater than 1.2 m.
8. Surface water drainage is somewhat poor to very poor.	8. Surfaces are moderate to well drained.

Figure 4. Suitable and unsuitable terrain characteristics for 4WD vehicle areas.

Topography. For user safety as well as environmental considerations, the average degree of slope for candidate areas should usually not exceed 30 to 35 percent. Traffic studies on Army vehicles that are similar to recreational 4WD vehicles indicate that vehicles of this type have only a fair probability of traveling over most soil surfaces located on slopes greater than 30 percent.[7] The following kinds of areas should be avoided:

1. Areas with several streams or which will require vehicles to execute many stream crossings.

[7] Trafficability of Soils: Soil Classification, Technical Memorandum No. 3-240, Sixteenth Supplement (U.S. Army Engineer Waterways Experiment Station, August 1961).

2. Areas with major streams or streams with high, steep banks.

3. Areas which contain a significant number of steep banks, cliffs, or deep gullies.

Vegetation. There are few limits on the types of suitable vegetation for candidate areas, except for those vegetation resources known to be very valuable or highly susceptible to damage (see Chapter 6). Areas which will require a minimal amount of site preparation (e.g., clearing) should receive first consideration. It is also important to note that immature trees can be damaged by 4WD vehicles and that a significant number of stumps in a candidate area can be a safety hazard. Areas where planting or harvesting are in progress should be avoided.

Water Table. Areas where the water table is generally less than 1.2 m deep should be avoided. Areas with somewhat poor to very poor internal and external drainage are unsuitable, because poor internal drainage removes water very slowly, keeping the soil wet most of the year; thus, the water table is usually less than 0.6 to 0.9 m below the surface. (Marshes, bogs, and swamps have this type of drainage.)

Seasonal Conditions. Seasonal variations in the water table, drainage, and soil wetness must be considered when evaluating areas for use by recreational 4WD vehicles. If an area is to be in use 12 months a year, suitability, as it relates to water table and drainage, should be based on wet season conditions. However, areas identified as unsuitable during wet season conditions might possibly be used during dry season conditions. Evaluation of areas to be used for only a portion of the year should be based on conditions which represent the wettest month during the proposed period of use.

Choosing the Areas

A site visit and visual survey of several areas or corridors on the installation should be conducted to determine their suitability for use and trail development. Areas to be surveyed should be chosen from the acreage which remains after all incompatible and noise-sensitive land use and noise buffer zones have been eliminated from consideration. (If it becomes necessary to select the limited-use alternative [Chapter 3], the acreage in noise buffer zones is not eliminated before areas are chosen; instead, use limits are established later based on the noise sensitivity of adjacent land uses.) During the site visit, the surveyor should identify characteristics which are both suitable and unsuitable for development.

Certain installation land areas (or portions of land areas) can be eliminated from consideration if they contain several unsuitable characteristics, as defined by the criteria listed above. However, certain areas with unsuitable terrain characteristics may still be considered if the trail is properly developed and maintained; e.g., constructing trails over the less steep slopes, bridging streams, using erosion controls, or removing large stones or boulders from trail corridors. (Some of the more expensive trail development and maintenance procedures may be provided through a cooperative agreement with user groups.)

Based on the field survey, at least two alternative candidate areas or corridors should be chosen. Candidate areas should contain a high percentage of suitable characteristics. These areas should be marked on the base map.

5 HOW TO EVALUATE SOIL SUITABILITY

Input

AR 210-9 requires that areas with soil properties which may be adversely affected by ORRVs be eliminated from consideration as ORRV-use areas. Therefore, soil suitability should be analyzed after candidate use areas or corridors are chosen. An effective way of doing this is to develop a soil limitations map. (Soil limitations maps are often used by land use planners to help select sites for a variety of activities, e.g., regional parks and subdivisions.)[8] To develop a soil limitations map, it will be necessary to obtain a recent soil survey of the candidate areas and to identify soil limitations ratings for 4WD vehicle use.

It is important to note that MIL-STD 619B, 12 June 1968, requires use of the Unified Soil Classification System (USCS) for Corps engineering projects. This is necessary to provide a general concept of the engineering characteristics of foundation, embankment, and filter materials. In this report, the emphasis on the suitability of soil is environmental. Consequently, the U.S. Department of Agriculture (USDA) Cooperative National Soil Survey Classification System is used. From an environmental point of view, properties that influence erodibility, trafficability, dustiness, and texture of the surface layer are important and these properties are reflected in the USDA classification system. Figures 5, 6, and 7 show the generalized relationship between the USCS, USDA, and other classification systems.

In addition to its suitability for addressing environmental concerns (wind and water erosion, etc.), the USDA Soil Conservation Service has a large collection of existing information which is readily available for environmental planning (saving the acquisition costs of new data). This system is based on the USDA designations.

Soil Surveys

Published county and area soil surveys for 175 counties in which 150 active Army installations are located indicate that about 70 percent of the installations are at least partially covered by a U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS) soil survey. These surveys are available from the State and local offices of the SCS.

Limitations Ratings

To help identify soil limitations ratings, CERL cooperated with the SCS in developing a guide for rating soils for off-road motorcycle trails (Table 3). By considering certain distinct differences between trailbikes and 4WD vehicles and their use, this guide can be used for evaluating areas for recreational 4WD vehicle use. For those users who are more familiar with the Unified Soil Classification System, most USDA soil surveys contain tables for comparing USDA and unified classifications. Using the guide, the tables, and

[8] L. J. Bartelli, et al., eds., Soil Surveys and Land Use Planning (Soil Science Society of America and American Society of Agronomy, 1966).

(This table may be used as a guide in classifying soils for which no engineering test data are available. The symbol > means "greater than;" the symbol < means "less than.")

USDA texture class and symbol	Unified symbol	AASHO symbol	Soil properties related to classifications
Clay, silty clay "C", "sic"	CH	A-7	High shrink-swell clays
	MH	A-7	Mica, iron oxide, kaolinitic clays
	CL	A-7	Low LL. Generally < 45 pct clay
Silty clay loam "sicl"	CL	A-7	Low LL. Plastic (A-6 if clay < 30 pct).
	ML-CL	A-7	Low LL. Mod. plastic (A-6 if clay < 30 pct).
	CH	A-7	High LL. High shrink-swell clays.
	MH	A-7	High LL. Mica, iron oxide, kaolinitic.
Clay loam "cl"	CL	A-6 or A-7	Low LL. Plastic
	ML-CL	A-6	Low LL. Moderately plastic.
	CH	A-7	High LL. High shrink-swell clays.
	MH	A-7	High LL. Mica, iron oxide, kaolinitic.
Loam "l"	ML-CL	A-4	Moderately plastic (A-6 if clay > 21 pct).
	CL	A-6	Plastic (A-4 if clay < 22 pct).
	ML	A-4	Low plasticity (A-7 if clay > 21 pct).
Silt loam "sil"	ML-CL	A-4	Moderately plastic (A-6 if clay > 21 pct).
	ML	A-4	Low plasticity (A-7 if clay > 21 pct).
	CL	A-6	Plastic.
"Silt - "si"	ML	A-4	Low plasticity.
Sandy clay "sc"	CL	A-7	Fines > 50 pct.
	SC	A-7	Fines 50 pct or less.
Sandy clay loam "scl"	SC	A-6	Plastic Fines 36-50 pct.
	SC	A-2-6	Plastic Fines 35 pct or less.
	CL	A-6	Plastic Fines > 50 pct.

Figure 5. General relationship of systems used for classifying soil samples. (From Janet S. Wright, Theodore C. Vogel, Alexander R. Pearson, and Jeffrey A. Messmore. Terrain Analysis Procedural Guide for Soil, ETL-0254 [U.S. Army Corps of Engineers, Engineer Topographic Laboratories, Fort Belvoir, VA, February 1981], p 35.)

Sandy loam "sl"	SM SC SM-SC	A-2-4 or A-4 A-2-4 A-2-4	Low plasticity. Plastic. Moderately plastic.
Fine sandy loam "fsl"	SM ML ML-CL SM-SC	A-4 A-4 A-4 A-4	Nonplastic Fines 50 pct or less. Nonplastic Fines > 50 pct. Moderately plastic. Fines > 50 pct. Moderately plastic. Fines 50 pct or less.
Very fine sandy loam "vfsl"	ML-CL ML	A-4 A-4	Moderately plastic. Low plasticity.
Loamy sands "ls", "lfs" "lvfs"	SM SM-SC SM ML	A-2-4 A-2-4 A-4 A-4	Nonplastic. Fines 35 pct or less. Moderately plastic. Fines 35 pct or less. Low plasticity. Fines > 35 pct. Little or no plasticity.
Sand, fine sand "s", "fs"	SP-SM SM SP	A-3 A-2-4 A-3	Fines approx 5-10 pct. Fines approx > 10 pct. Fines < 5 pct.
Very fine sand "vfs"	SM ML	A-4 A-4	Low plasticity. Little or no plasticity.
Coarse sand "cs"	SP, GW SP-SM SM SM	A-1 A-1 A-1 A-2-4	Fines < 5 pct. Fines 5-12 pct. Fines 13-25 pct. Fines > 25 pct.
Gravel, "G" 50 pct passes No. 200 50 pct of coarse passes No. 4 sieve	CP, GW GM or GC GM or GC GM GC	A-1 A-1 A-2 A-4 A-6	Fines < 5 pct. Fines 5-25 pct. Fines 26-35 pct. Fines > 35 pct. Fines > 35 pct.

Figure 5 (Cont'd).

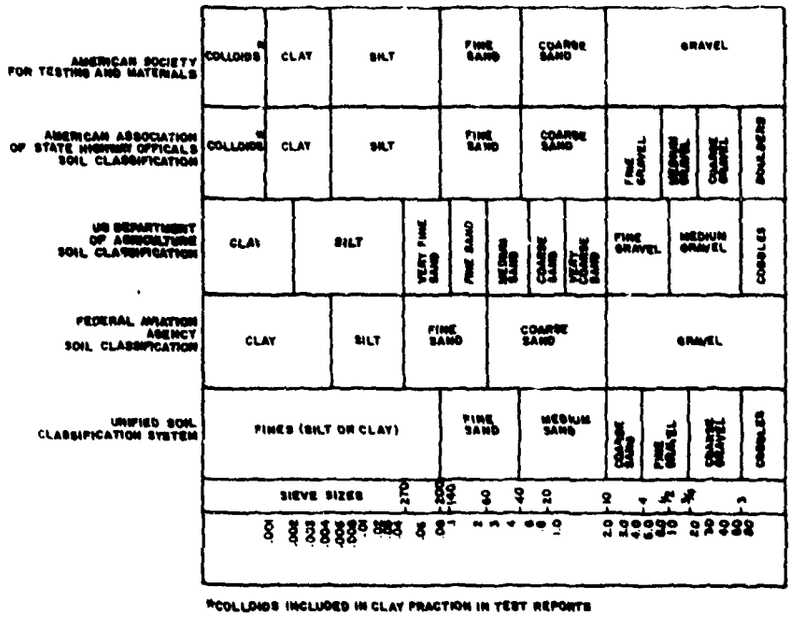

Figure 6. Comparison of particle size limits for selected soil classification systems. (From PCA Soil Primer, [Portland Cement Association, 1973].)

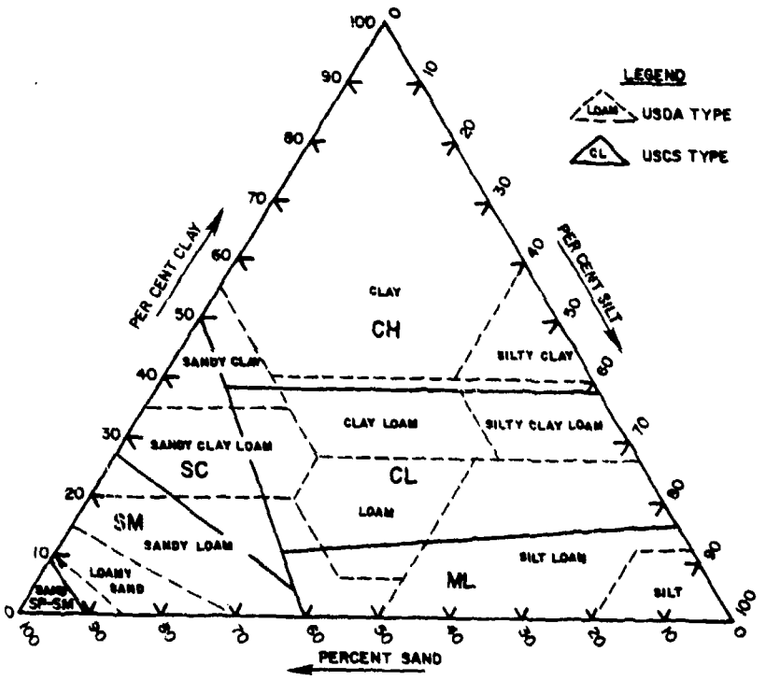

Figure 7. Guide for comparing USDA and USCS soil types. (From Trafficability of Soils, Soil Classification, TM 3-240 [Waterways Experiment Station, 1961].)

Table 3

Guide for Rating Soil Limitations
for ORRV Trails

	Property	Limits: Slight†	Moderate†	Severe†	Restrictive Feature
1.	USDA texture	---	---	ICE	Permafrost
2.	Fraction > 3 in. (86 mm) (wt pct) (surface layer)*	<10	10-25	>25	Large stones
3.	Depth to high water table (ft)*	>2 ---	1-2 ---	0-1 +	Wetness Ponding
4.	Erosion factor (K) x pct slope	<2	2-4	>4	Erodes easily
5.	USDA texture (surface layer)**	---	---	SC, SIC, C	Too clayey
6.	USDA texture (surface layer)	---	LCOS, VFS	COS, S, FS	Too sandy
7.	Unified (surface layer)	---	---	OL, OH, PT	Excess humus
8.	Slope (pct)	0-25	25-40	>40	Slope
9.	Coarse fragments (wt pct) (surface layer)+	<40	40-65	>65	Small stones
10.	USDA texture (surface layer)	---	SIL, SI VFSL, L	---	Dusty
11.	Flooding	NONE, RARE, OCCAS	FREQUENT	---	Floods
12.	Other++	---	---	---	Fragile

* 1 in. = 25.4 mm; 1 ft = 0.3048 m.
** Soils in UST, TOR, ARID, BOR, or XER suborders, great groups, or subgroups rate one class better.
\+ 100 minus percent passing No. 10 sieve.
++ If the soil is easily damaged by use or disturbance, rate as "Severe-Fragile."
† See Table 4 for definitions of abbreviations.

the special considerations, soils in candidate areas can be rated as having slight, moderate, or severe limitations for use. These ratings are defined as follows:

Slight. Given to soil phases that have properties acceptable for use. The degree of limitation is minor and environmental damage is expected to be below average. Good performance and low maintenance can be expected.

Moderate. Given to soil phases that have properties moderately acceptable for use. The degree of limitation can be overcome or modified by special planning, design, or trail maintenance. Some soils rated as moderate require artificial drainage, control of runoff to reduce erosion, some modification of certain features through manipulation of the soil, etc.

Severe. Given to soils that have one or more properties that are unacceptable for use, such as steep slopes, large stones, flooding, a seasonal high water table, or a high erodibility factor. This degree of limitation generally requires major soil reclamation, special design, or intensive maintenance. Some of these soils can be improved by reducing or removing the soil feature that limits use, but in most situations, it is difficult and expensive to alter the soil or to design the trail to compensate for a severe degree of limitation.

The limitations ratings for the soils of a particular candidate area can be identified from information obtained from either State or local SCS offices or major command (MACOM) natural resources offices.

SCS Offices. As noted, the guide in Table 3 was developed by CERL and the SCS. The SCS has developed similar guides for other uses, e.g., playgrounds and septic tank absorption fields. The interpretation of soil suitability for these other uses is part of the National Cooperative Soil Survey being conducted by the SCS. Since its development, Table 3 has been included in the National Soils Handbook with these other guides. As a result, personnel in the State or local SCS offices should be familiar with Table 3 and should be able to help determine soil suitability for 4WD vehicle use.

To get help from the SCS, the user should:

1. Identify the candidate areas on soil survey maps.

2. Prepare a list of each soil series included in the candidate areas.

3. Take the soil survey map(s), a copy of Table 3, a copy of the special 4WD considerations, and the soil list to the appropriate State or local SCS office.

MACOM Offices. Installation personnel who cannot obtain the services of a professional soil scientist should get soil rating information from their MACOM natural resource offices. Information on every United States soil series and phase which has been identified and classified by the SCS is stored in computer files. After each new rating criterion is developed and tested, the soil property information in these files is evaluated and the soils rated according to the criterion. The rating and suitability information for each soil is then printed and distributed. Accordingly, these files are accessed

and ratings developed using the evaluation criteria (Table 3). This is done using a computer program and with the help of the Statistical Laboratory and Department of Statistics at Iowa State University, where the soil records are kept.

Because of the number of soils involved, a copy of these ratings is very large. Therefore, they received limited distribution. The limitations ratings and a detailed description of their use are available from the Command Natural Resource Offices of the Training and Doctrine Command (TRADOC) and Forces Command (FORSCOM) and the Natural Resources Section of the Installation and Services Activity, Materiel Development and Readiness Command (DARCOM). To obtain soil ratings from these offices, the user should list each soil series included on the soil survey map(s) of the candidate areas and ask for their limitations ratings from the appropriate MACOM office.

The remainder of this chapter describes how soils were rated, how ratings are interpreted, how the special 4WD vehicle considerations are incorporated into these ratings, and how the ratings are used.

Alternative Input and Procedures

The method of evaluating soil suitability described in this report assumes that the soils of a candidate area have been identified and that there is a recent SCS or similar quality soil survey for the area. However, this may not always be the case. The soils of a candidate area -- or of an entire installation -- may never have been surveyed. If a survey has been completed, it may only represent general soil associations or it may be out of date. If a county survey has been prepared, the lands within installation boundaries may not have been included. In all these instances, the method described in this chapter cannot be used. Instead, more technical soil analysis and rating procedures which have been developed as a supplement to the ORRV evaluation method must be used. These supplemental procedures are described in Volume II of CERL Technical Report N-86, which is available from the MACOM offices identified above and the National Technical Information Service, Springfield, VA.[9]

Soil Ratings

The following paragraphs describe how the soil ratings available from the MACOM natural resource offices were developed and how they are interpreted.

How Soils Were Rated

The soil rating criteria (Table 3) identify eight different soil properties which have the potential to restrict or limit a soil's suitability for ORRV use. These are USDA texture, the weight percentage of stones greater than 3 in. (76 mm), depth to high water table, erosion factor (K), slope, unified texture, the weight percentage of coarse fragments less than 3 in. (76 mm) but greater than 2 mm, and flooding. The differences in these properties create up to 11 possible restrictive features. (Note that restrictive feature

[9] R. M. Lacey and H. E. Balbach, Evaluation of Areas for Off-Road Recreational Motorcycle Use, Volume II: Alternate Soil Suitability Determination Methods, Technical Report N-86/ADA096529 (CERL, November 1980).

12 in Table 3 cannot be determined using computer analysis. It is only determined in the field and through professional experience.)

Each of the 11 possible restrictive features in Table 3 is listed in the order of its importance as a limiting factor. The properties of each soil in the SCS files were examined according to this order. For example, when the computer examined the properties of a particular soil, it searched for an indication of permafrost before an indication of the presence of large stones or wetness. The computer-generated limitations ratings for a particular soil identify a maximum of three restrictive features; these features are also given in their order of importance. For example, consider a particular soil that has severe limitations because it has a very high water table, erodes easily, is too clayey, and has excess humus. The limitations ratings will only indicate that it has severe limitations for wetness, erodes easily, and is too clayey. Of the four limitations, these three are considered more important as indicated by their order as restrictive features in Table 3.

Soil properties were also examined on a worst-case basis, with severe limitations being the worst case. For example, if 15 percent of the weight percentage of a particular soil is due to large stones (a moderate limitation) and another 70 percent is due to small stones (a severe limitation), the soil will be rated as having severe limitations due to small stones. The moderate restriction due to large stones is not indicated in the rating, even though large stones are higher in importance as a restrictive feature. Only the worst case or most severe limitations (and appropriate restrictive features) are identified in the soil limitations ratings.

How Ratings Are Interpreted

Figure 8 shows how soil limitations ratings are generated by the computer. The initial step in identifying the soil limitations for the soils in a particular candidate area is to consult the soil survey and soil maps of the area. The legend for the map(s) will generally identify the soils by phase description (see paragraph number 4 below). If a soil's phase description is not given, it may be possible to identify it from information in the text of the survey.

After phase descriptions for the area's soil are identified, they should be compared with the various phase descriptions on the limitations ratings. The limitation for the soil phase on the ratings list which most closely approximates the phase description in the survey is the degree of limitation given to the soil or mapping unit. The phase descriptions on the ratings and in the survey do not have to and, in fact, generally will not, correspond exactly. Good judgment should be used to pick the rating which most closely applies to the survey description.

The following information will help the user select the appropriate rating:

1. Soil Series. Under this column are listed, in alphabetical order, soil series names for soils which have been identified and classified by the SCS. In many cases, a series name will be listed two or more times, once by itself and again followed by a property or unit modifier, e.g., stony, moderately wet, flooded. The limitations for a soil unit that is modified by

SOIL SERIES	RECORD NUMBER	DEPTH (IN.)	PHASE	LIMITATION	RESTRICTION
ADELPHIA	WJ0024	0-14	0-6% SL,FSL	MODERATE	WETNESS
			6-10% SL,FSL	MODERATE	WETNESS, ERODES EASILY
			0-6% SIL	MODERATE	WETNESS, DUSTY
ADENA	C00194	0-3	0-5% L,SIL	MODERATE	DUSTY
			5-11% L,SIL	MODERATE	ERODES EASILY, DUSTY
			11-12% L,SIL	SEVERE	ERODES EASILY
ADGER	MT0001	0-7	0-4% C,SIC	MODERATE	TOO CLAYEY
			4-8% C,SIC	MODERATE	ERODES EASILY, TOO CLAYEY
			0-4% SICL	SLIGHT	
			4-8% SICL	MODERATE	ERODES EASILY
ADILIS	C00468	0-4	0-8% GR-SL	MODERATE	SMALL STONES
			0-8% GR-L	MODERATE	SMALL STONES, DUSTY
			0-8% SL	SLIGHT	
			0-8% L	MODERATE	DUSTY
ADJUNTAS	PR0063	0-24	40-60% C	SEVERE	ERODES EASILY, TOO CLAYEY
ADKINS, ALKALI	µ40249	0-11	0-3% FSL	MODERATE	WETNESS
ADKINS, GRAVELLY SUBSTRATION	µ40470	0-4	0-6% FSL	SLIGHT	
			6-13% FSL	MODERATE	ERODES EASILY
			13-15% FSL	SEVERE	ERODES EASILY
ADKINS, WET	µ40623	0-12	0-6% FSL	MODERATE	WETNESS
			6-13% FSL	MODERATE	WETNESS, ERODES EASILY
			13-15% FSL	SEVERE	ERODES EASILY
ADLER	µ50024	0-7	0-2% SICL,RARE,OCCAS	SLIGHT	
			0-2% SICL,FREQ	MODERATE	FLOODS
			0-2% SIL,SI,RARE,OCCAS	MODERATE	DUSTY
			0-2% SIL,SI,FREQ	MODERATE	DUSTY, FLOODS
ADOLPH	MN0188	0-13	0-1% SICL,SIL	SEVERE	WETNESS
ADRIAN	µ10028	0-34	0-2% SP	SEVERE	PONDING, EXCESS HUMUS
ACET	I00045	0-5	0-12% SL	SLIGHT	
			0-6% L	MODERATE	DUSTY
			6-12% L	MODERATE	ERODES EASILY, DUSTY
AECET, STONY	ID0046	0-5	0-12% STV-SL,STV-LS	SEVERE	LARGE STONES

Figure 8. Sample soil limitations ratings.

a certain property or characteristic can be very different from the limitations of the unmodified soil.

2. Record Number. This column contains the record number of each soil series and/or modified series. This number is used by the SCS for record-keeping and indicates, by abbreviation, the state in which the records for the soil are kept. If more information is needed on a particular soil, this record number can be used in correspondence with the appropriate SCS office. This need may arise if there is any uneasiness about a rating or if suggestions for soil maintenance procedures are desired.

3. Depth in Inches. Individual soil depths vary considerably. The properties of a particular soil will change at varying depths. The numbers in this column identify the soil depth to which the rating has been applied. If erosion has or does occur to a depth greater than that indicated, it will be necessary to consult a professional soil scientist to determine the correct limitation rating of the exposed soil.

4. Phase. A soil series can have several phases, depending on the slopes on which it is found, its predominant surface texture at a particular location, the presence of stones, flooding potential, and other characteristics. A soil's limitation and/or restrictive features can, and generally do, change from phase to phase. Therefore, based on the rating criteria, all possible phases of a particular soil series are listed in this column. Table 4 lists abbreviations which can be used to interpret phase differences. For example, "6-10% SL, FSL" is one possible phase for a soil found in New Jersey (Adelphia in Figure 8). The abbreviations indicate that the corresponding limitation for this phase is applied to this soil if it is found on 6 to 10 percent slopes and the predominant surface texture is sandy loam or fine sandy loam.

5. Limitation. This column identifies the limitation rating which applies to each soil series phase. The possible limitations are slight, moderate, or severe.

6. Restriction. This column identifies the restrictive feature which resulted in a soil phase being given a moderate or severe limitation, e.g., too sandy, slope. No restrictions are given if the phase has only slight limitations.

As an example of interpreting the limitations rating for a particular phase, consider the Adena soil series listed in Figure 8. The records of this soil's properties are on file at the Colorado State SCS office under the record number C00194. Limitations ratings for various phases of this soil apply to the first 3 in. (76 mm) of soil. If the soil is found on 0 to 5 percent slopes and the predominant texture is loam (L) or silt loam (SIL), it has moderate limitations because it is dusty. If the same textures are found on 5 to 11 percent slopes, it also has moderate limitations. However, the principal restrictive feature in this case is that the soil erodes easily when found on these slopes (even though it is still dusty).

Table 4

Soil Phase Interpretation Abbreviations

Abbreviations for Texture Modifiers

		GR	Gravelly
BY	Bouldery	GRC	Coarse gravelly
BYV	Very bouldery	GRF	Fine gravelly
BYX	Extremely bouldery	GRV	Very gravelly
CB	Cobbly	MK	Mucky
CBA	Angular cobbly	PT	Peaty
CBV	Very cobbly	SH	Shaly
CN	Channery	SHV	Very shaly
CNV.	Very channery	SR	Stratified
CR	Cherty	ST	Stony
CRC	Coarse cherty	STV	Very stony
CRV	Very cherty	STX	Extremely stony
FL	Flaggy	SY	Slaty
FLV	Very flaggy	SYV	Very slaty

Abbreviations for Texture

COS	Coarse sand	VFSL	Very fine sandy loam
S	Sand	L	Loam
FS	Fine sand	SIL	Silt loam
VFS	Very fine sand	SI	Silt
LCOS	Loamy coarse sand	SCL	Sandy clay loam
LS	Loamy sand	CL	Clay loam
LFS	Loamy fine sand	SICL	Silty clay loam
LVFS	Loamy very fine sand	SC	Sandy clay
COSL	Coarse sandy loam	SIC	Silty clay
SL	Sandy loam	C	Clay
FSL	Fine sandy loam		

Abbreviations for Terms Used in Lieu of Texture

CE	Coprogenous earth	MARL	Marl
CEM	Cemented	MPT	Mucky-peat
DE	Diatomaceous earth	MUCK	Muck
FB	Fibric material	PEAT	Peat
FRAG	Fragmental material	SG	Sand and gravel
G	Gravel	SP	Sapric material
GYP	Gypsiferous material	UWB	Unweathered bedrock
HM	Hemic material	VAR	Variable
ICE	Ice or frozen soil	WB	Weathered bedrock
IND	Indurated	CIND	Cinders

Abbreviations for Frequency of Flooding

NONE	NONE (No reasonable possibility of flooding)
RARE	RARE (Flooding unlikely but possible under abnormal conditions)
COMMON	COMMON (Flooding likely under normal conditions)
OCCAS	OCCASIONAL (Less often than once in 2 years)
FREQ	FREQUENT (More often than once in 2 years)
PROT	PROTECTED (Soil protected from flooding; e.g., levees)

Unique Soils and Professional Review

In most soil surveys, there will be a few areas that are mapped but not identified as containing a singular soil series or phase. These may be areas where:

1. The soils have been disturbed, e.g., landfills

2. Areas where the soil exhibits no particular properties which would give it a special classification, e.g., alluvial soils

3. Areas where a variety of intermingled series exist such that it would be difficult to plot their boundaries on a map

4. Areas where no soil has been developed, e.g., granite outcrops. In these cases, the identification of a degree of limitation may be difficult, since the soils will not be listed in the limitations ratings.

Many times, a soil survey will have brief written descriptions of these mapping units. These descriptions can be compared to the rating criteria to obtain an estimate of the degree of limitations. However, for most cases, it is recommended that a professional soil scientist be consulted to obtain a more accurate estimate of their degree of limitation.

It should be noted that the information in the SCS soil files is continually updated and that the criteria used to develop the ratings have not been extensively tested. As a result, and at the request of SCS personnel, it is recommended that the use of the ratings and the soil evaluation method be coordinated with or reviewed by local SCS field personnel, where possible. This is to insure that any potential problems which may result in environmental damage will be identified early in the planning of an ORRV-use area. And because of the unique nature of tropical and permafrost soils, it is strongly recommended that a professional soil scientist be consulted concerning the ratings for soils in Alaska and Hawaii.

Special 4WD Vehicle Considerations

The fundamental differences between 4WD vehicles and trailbikes are that 4WD vehicles are larger, heavier, and have four wheels touching the ground. Also, 4WD vehicles are generally operated at a much lower average speed. These differences make 4WD vehicles more stable, but also make them more likely to become stuck and damage soil surfaces.

When soils are evaluated according to the criteria in Table 3, limitations ratings for six of the first 11 restrictive features should be the same for 4WD vehicles and trailbikes. However, for five of the features -- large stones, wetness, too sandy, slope, and floods -- the ratings may have to be modified. The following text briefly describes the modifications or considerations which should be taken into account when soil ratings for the soils in a 4WD candidate use area are received from MACOM natural resource offices or when coordinating ratings with soil scientists.

Large Stones

Recreational 4WD vehicles usually can travel over surfaces with a considerable number of large stones; i.e., stones larger than 3 in. (76 mm) but less than 10 in. (250 mm) in length or width. As a result, soils rated as having moderate limitations for trailbike use due to large stones will have only slight limitations for 4WD vehicle use. Soils with severe limitations for trailbike use due to large stones will have only moderate limitations for 4WD vehicle use, unless more than 35 percent of the soil's surface is covered by large stones or boulders. If more than 35 percent of a soil's surface is covered by large stones or boulders, the soil has severe limitations for 4WD vehicle use due to large stones. The percent surface coverage of large stones can be estimated by a visual survey, by measuring, or by a point-count system. Simple procedures to conduct these analyses are described in Volume II of CERL Technical Report N-86, in the soil supplement to the ORRV method.

Wetness

Soils rated as having moderate or severe limitations for trailbike use due to wetness will have severe limitations for 4WD vehicle use. Soils with a seasonally high water table of 2 to 4 ft (0.6 to 1.2 m) will have moderate limitations for 4WD vehicle use due to wetness. Soils with a water table greater than 4 ft (1.2 m) will have slight limitations for 4WD vehicle use due to wetness. The depth to the water table can be determined by records or by digging holes; Volume II of CERL Technical Report N-86 describes simple techniques to do this.

Too Sandy

Soils rated as having moderate or severe limitations for trailbike use because they are too sandy will have severe limitations for 4WD vehicle use.

Slope

Slopes have moderate limitations for trailbike use if they are between 25 and 40 percent and severe limitations if they are greater than 40 percent. For 4WD vehicles, slopes have moderate limitations if they are between 15 and 35 percent and severe limitations if they are greater than 35 percent. A soil's degree of slope can generally be determined from the soil survey description of the soil. It can also be identified from topographic maps or during a field survey. (Also see Volume II of CERL Technical Report N-86.)

Floods

Soils that are subject to frequent flooding -- i.e., more often than once in 2 years -- have moderate limitations for trailbike use, but severe limitations for 4WD vehicle use. Soils that are subject to occasional flooding -- i.e., less often than once in 2 years, but likely under normal conditions -- have slight limitations for trailbike use, but moderate limitations for 4WD vehicle use. The probability of flooding can generally be identified from the soil survey description of a soil. It is also indicated in the phase descriptions in the soil limitations ratings. Table 4 lists the abbreviations used to identify flooding frequencies in the limitations ratings.

Mapping Soil Limitations

To prepare the limitations map of the soils within a candidate area, the soil series map(s) in the soil survey which corresponds to the area should be reproduced. This map will show the boundaries of each soil series or phase. (In most cases, the soil limitations map will be prepared separately from the base map [Chapters 2, 3 and 4]; only if the scale of the soil survey map and the base map are the same, or can be made to correspond through reproduction, can the boundaries of each soil series phase be placed on the base map.) The limitations map is prepared by coloring the soil series phases or map units within their respective boundaries. Yellow (caution) is used for soil phases having moderate limitations; red (stop) is used for soil phases with severe limitations. Soil phases with slight limitations are not colored. Remember that soil limitations ratings for the soils on the map should reflect the special 4WD vehicle considerations.

Based on the soil limitations map, candidate areas (or portions of candidate areas) can be eliminated from consideration for use. Generally, those areas which are eliminated contain soils which have severe limitations. Since the ratings identify restrictive features, the reason(s) why areas are eliminated can be documented easily. However, certain areas or trail corridors where soils have severe limitations, as well as areas where soils have moderate limitations, may be considered for use if proper maintenance or mitigation procedures can be used to balance the effect of the restrictive features, e.g., removing large stones or constructing runoff control terraces. Areas or corridors with slight limitations can be considered acceptable for use, subject to further evaluation (Chapter 6). If the acreage where the soils are acceptable is not large enough for 4WD vehicle use (e.g., less than 16 ha or trails less than 16 km long), it may be necessary to choose new candidate areas or trail corridors. All areas in which the soils are unacceptable and, if necessary, all new candidate areas should be marked on the base map. The soils of any new candidate areas should be evaluated as described above. Acceptable areas, relative to soils, should then be evaluated using the environmental considerations described in the following chapters and in the appendices.

6 HOW TO EVALUATE BIOLOGICAL SUITABILITY

Input

AR 210-9 requires that an evaluation of areas for potential ORRV use include an examination and assessment of the biological resources of those areas. This examination should, at the minimum, determine the value of the biological elements within candidate areas. If possible, it should also consider the possible impact of ORRV use on biological resources. To make an effective examination, a site visit and visual survey of candidate areas should be conducted. The survey should be done by a professional biologist with field qualifications. If a biologist is not assigned to the installation, the U.S. Fish and Wildlife Service (USFWS) should be consulted. (AR 420-74 gives conditions for USFWS cooperative agreements.)[10] During the site visit, the surveyor should determine if significant plant and animal species or critical habitat are present.

Endangered Species

Any candidate area which contains a rare, endangered, or threatened plant species (as defined by Federal or State law), or locally important plant and animal populations (e.g., remnant prairie land) should be eliminated from consideration. No area containing a rare, endangered, or threatened animal species at any season of the year should be opened to 4WD vehicle use until a site visit by the USFWS has confirmed that the species will not be adversely affected by the use of 4WD vehicles on or near that area.

Biological Ranking

After thorough examination of each alternative site, the biologist should rank areas or corridors according to their acceptability for use. Research designed to identify the biological effects of 4WD vehicle operation and to describe the mechanism of such effects is limited and primarily restricted to desert environments. In general, it is known that the operation of 4WD vehicles will (1) cause loss of habitat due to soil compaction which will restrict plant growth, (2) directly destroy habitat due to mechanical injury to plants, and (3) have generalized adverse effects on animal populations due to the increased presence of humans and their machines. However, an exact prediction of how much damage will be caused by how many machines is not possible. Therefore, the biological ranking of an area will rely on structured professional judgment.

To be effectively ranked, alternative areas or corridors must be examined using comparable factors. A system to compare biological resources, including user instructions, is described below. This system is designed to be used even if quantitative data are not available. (Note that the system requires the input of a professional biologist.) Alternative candidate areas can be rated in either of two ways: (1) the "relative value" of the biological

[10] Natural Resources -- Land, Forest, and Wildlife Management, AR 420-74 (DA, 1 July 1977), p 2-2.

resources of alternative areas can be examined in relation to the rest of the installation, or (2) the "susceptibility to ORRV damage" of alternative areas can be examined. (The latter is used only if the biologist is familiar with the types of damage that will result from ORRV operation.) For both methods, year-round as well as seasonal conditions should be considered.

User Instructions

The following instructions are accompanied by an example for a hypothetical area. The example for the "relative value" approach is shown in Figure 9. The example for the "susceptibility to ORRV damage" approach is shown in Figure 10. A blank copy of the form used in Figures 9 and 10 is provided in Appendix B for reproduction purposes. The circled numbers by each step in the instructions refer to corresponding numbers in Figures 9 and 10. They are given to illustrate the portion of the rating form which relates to each step.

The "Relative Value" Approach

Area. Assign a special designation to each alternative area. The designation is used to identify one area from another (e.g., "Area 1"). If a candidate area represents two or more distinct biological communities, the areas covered by the different communities should be considered separately.

Biological Resources. Several categories of biological resources are listed in this column, e.g., "Ground Cover," "Trees or Dominant Vegetation." Under each category, list specific biological resources which are known to exist either in the area being examined or on the installation, e.g., "Ashe Juniper" or "Live Oak." If dominant vegetation can be placed into both "Ground Cover" and "Trees or Dominant Vegetation," it is to be included in both categories. "Terrestrial Nongame Animals" includes both birds and reptiles. If a water body or stream is in or near the area being examined, include fish. Identify any other species or biological factor which is not easily categorized by listing it under the category "Other." The list of biological resources should be compiled from existing data, but remember that a site visit is also required. The last column in the special rating form gives space for any remarks or notes which may help rate an area.

Relative Value. In this column of the evaluation form, rate each listed biological resource. The value of the resources at each site should be rated relative to their value on the rest of the installation. When determining this value consider the past, present, and future carrying capacity of the area in relation to the rest of the installation. (The relative value is determined using the five-point scale in Table 5.)

Categorical Value. Next, determine the "relative value" of each of the resource categories for which biological resources were identified. To do this, take the highest individual biological resource value under each category and assign that value to the entire category. For example, in Figure 9, the biological resources "Ashe Juniper" and "Live Oak" have been given values of 2 and 4, respectively. Since "Live Oak" was given a value of 4, the entire resource category of "Trees or Dominant Vegetation" should be given a value of 4, the highest "relative value" in that category.

(1) Area AREA 1

(6) Rating 3.6 Rank 2 (8)

(7) Biological Limitation TERRESTRIAL GAME ANIMALS, EXCEPTIONALLY GOOD HABITAT FOR FOX SQUIRREL AND BOBWHITE

(2) Biological Resources	(3) Relative Value	(4) Categorical Value	Susceptibility to ORRV Damage	Categorical Susceptibility	Combined Resource Value	Notes
Ground Cover		3				
GRASSES CACTUS	3 5					ON ROCKY SURFACES
Trees or Dominant Vegetation		4				
ASH JUNIPER LIVE OAK	3 4					
Terrestrial Game Animals		5				
WHITE-TAILED DEER FOX SQUIRREL EASTERN COTTONTAIL BOBWHITE MOURNING DOVE TURKEY	3 5 5 5 4 2					MANY DEN TREES
Terrestrial Nongame Animals		3				
TEXAS ALMING COLLARED LIZARD TURKEY VULTURE LARK SPARROW CARDINAL	5 2 5 3 3					
Fish		3				
LONGNOSE GAR CARP CHANNEL CATFISH EDWARD SHAD CHANNEL CATFISH	1 2 1 2 3					
Pest species		3				
STARLING BLACK ANT RATTLESNAKE	2 2 3					WINTERING AREA/ PERIODIC HIGH CONCENTRATIONS
Other		4				
DEN TREES	4					
(5) Total Area Value		25	Total Combined Resource Value			

Figure 9. The "relative value" approach to ORRV-use potential.

Area AREA 1

(5) Rating 136 Rank 3 (7)

Biological Limitation Terrestrial Game Animals, particularly the presence of Fox squirrel (6)

(1) Biological Resources	Relative Value	Categorical Value	(2) Susceptibility to ORRV Damage	(3) Categorical Susceptibility	(4) Combined Resource Value	Notes
Ground Cover		3		4	12	
GRASSES	2		2			ON ROCKY SURFACES
CACTUS	3		4			
Trees or Dominant Vegetation		4		3	12	
ASHE JUNIPER	2		3			
LIVE OAK	4		3			
Terrestrial Game Animals		5		5	25	
WHITE-TAILED DEER	3		3			MANY DEN TREES
FOX SQUIRREL	5		3			
COMMON GRACKLE	5		2			
RACCOON	4		2			
MARYLAND DOVE	4		2			
TURKEY	2		4			
Terrestrial Nongame Animals		3		3	9	
TEXAS MOUSE	3		2			
COLLARED LIZARD	2		3			
TURKEY VULTURE	2		2			
LARK SPARROW	3		3			
CARDINAL	3		3			
Fish		3		4	12	
LONGNOSED GAR	1		2			
CARP	2		2			
FLATHEAD CATFISH	2		2			
GIZZARD SHAD	5		3			
CHANNEL CATFISH	5		4			
Pest species		3		3	9	
STARLING	3		4			WINTERING AREA/ PERIODIC HIGH CONCENTRATIONS
BLACK RAT	3		3			
RATTLESNAKE	3		3			
Other		4		4	16	
DEN TREES	4		4			
Total Area Value {			Total Combined Resource Value {		95	

Figure 10. The "susceptibility to ORRV damage" approach to ORRV-use potential.

Table 5

Scale for Rating the Relative Value of
Biological Resources

Relative Value of the Biological Resource	Rating
o The resource has little importance at this location when compared to the rest of the installation.....	1
o The resource has some importance at this location, but its value is somewhat below average as compared to the rest of the installation..	2
o The resource at this location is representative of the entire installation.....	3
o The area is one of the better examples of this resource relative to the rest of the installation. The value of the resource at this location can be described as somewhat above average.....	4
o This area is one of the very best examples of this resource as compared to the rest of the installation. The value of the resource at this location can be described as much more valuable than at other locations on the installation.....	5

Total Area Value. Determine the "relative value" of the entire area by adding the category values. For example, the total area value of 25 in Figure 9 was determined by adding the values for the categories "Ground Cover," "Trees or Dominant Vegetation," "Terrestrial Game Animals," "Terrestrial Nongame Animals," "Fish," "Pest Species," and "Other."

Rating. Determine the biological rating of the area by dividing the total area value by the number of resource categories for which values have been determined. In Figure 9, 25 has been divided by 7 for a value of 3.6. If the category "Other" had not contained a value, the total area value would have been divided by 6. After determining the area rating, write it in the space provided near the top of the form. This allows for a quick comparison of alternative areas.

Biological Limitation. For decision-making purposes, the biological limitation of the area must be noted. The biological limitation is the resource category which has received the highest "categorical value." For example, in Figure 9, the biological limitation for the hypothetical area is the presence of "Terrestrial Game Animals," particularly Fox Squirrel and Bobwhite. The biological limitation shows which resource places the greatest restriction on possible ORRV use in the area. When describing the limitation, briefly explain the importance of the resource. Word the explanation so a nonbiologist can understand the logic.

Rank. The final step in this approach is to rank alternative areas. To do this, compare the biological ratings and limitation of each area. Rank the area with the lowest numerical rating No. 1. This indicates that the area is the most acceptable for ORRV use. Rank the area with the second lowest rating No. 2. Indicate any area with a biological rating of greater than or equal to 4 as unacceptable. An area with an overall rating of 4 is one of the better examples of biological resources relative to the rest of the installation. Therefore, the area should not be used. If two areas receive the same rating, use individual judgment to determine the importance of the biological limitation before assigning the areas a ranking number. The area which is most important biologically should always receive the highest numerical value in rank.

The "Susceptibility to Damage" Approach

This approach is used only if the biologist examining the alternative areas feels qualified to determine the susceptibility to damage of those biological resources known to exist in the areas.

Initial Steps. The first four steps of this approach are the same as those listed in the "relative value" approach. After completing those steps, follow the steps listed below.

Susceptibility to ORRV Damage. Determine the susceptibility to damage of each of the biological resources listed under the resource categories and, in this column, assign a susceptibility value to each resource. Since the importance of damage to various resources is perceived differently, use the two separate scales in Table 6 to assign the values. One scale applies to all resource categories except "Pest Species"; the other is used exclusively for "Pest Species."

Categorical Susceptibility. Determine the "susceptibility to ORRV damage" for each resource category by assigning to the entire category the susceptibility value of that resource which received the highest relative value. For example, in Figure 10, the biological resource "Fox Squirrel" has a relative value of 5. Since it is the highest "relative value" for any resource in the category "Terrestrial Game Animals," the entire category receives a "susceptibility to ORRV damage" value of 5, the susceptibility value for Fox Squirrel.

Combined Resource Value. Determine the combined resource value of each resource category by multiplying the relative values by the susceptibility to damage values. In Figure 10, the "relative value" of the category "Ground Cover," 3, is multiplied by the "susceptibility to ORRV damage" value, 4. This results in a combined resource value of 12. Determine the combined resource value of the entire area by adding the combined resource values for each category. In Figure 10, this results in a total combined resource value of 95.

Rating. Determine the biological rating for the entire area by dividing the total combined resource value by the number of resource categories for which combined resource values have been determined. In Figure 10, 95 has been divided by 7 for a rating value of 13.6. (Note that if the category "Other" had not contained a susceptibility value, the area's combined resource

Table 6

Scales for Rating the Susceptibility to Damage of Biological Resources

Susceptibility to Damage of the Biological Resource	Rating
NONPEST SPECIES	
o This resource will receive some damage as a result of ORRV use. Recovery time for the resource would be within 1 year OR the area is already so badly damaged from other factors that it has no logical present or future biological value.....	1
o This resource will be damaged by ORRV use. Recovery time for this resource would be from 1 to 5 years.....	2
o ORRV use would be destructive to this resource. Recovery time for this resource would be from 5 to 10 years.....	3
o ORRV use would be highly destructive. Recovery time for this resource would be from 10 to 100 years.....	4
o ORRV use would be extremely destructive to this resource. If use is allowed, the recovery time would be greater than 100 years...	5
PEST SPECIES	
o ORRV use would cause no increase in this species through habitat improvement and/or a reduction in competition OR any prediction of decrease in the species is also indicated by a value of 1.....	1
o ORRV use would cause a slight increase in this species.....	2
o A moderate increase in this species is expected as a result of ORRV use.....	3
o A large increase in this species is expected as a result of ORRV use.....	4
o ORRV use would reduce competition and/or improve habitat for this species such that a very large increase in the pest population is expected.....	5

value would have been divided by 6.) As in the "relative value" approach, the area rating is placed in the space provided near the top of the evaluation form.

Biological Limitation. To help in the decision-making process, the biological limitation of an area must be recorded. Determine the limitation by examining the combined resource value of each resource category. The highest individual category value determines the biological limitation. In Figure 10, the limiting factor is "Terrestrial Game Animals." This resource category has a combined resource value of 25, the highest of all categories. In this case, the presence of "Fox Squirrels" (which will be significantly affected by ORRV use) presents the greatest biological restriction.

Rank. To rank areas, compare the biological rating for each alternative site. Rank the area with the lowest numerical rating No. 1. The area with this ranking is the most acceptable for ORRV use. Any area which has a rating of greater than or equal to 16 is not normally acceptable for ORRV use. A rating of 16 or greater indicates that the area has excellent resources relative to the rest of the installation and ORRV use would be relatively more destructive.

Rank Interpretation

The ranking of alternative candidate areas gives the decision-maker valuable, documented information for selecting areas for potential trail development.

As stated in the instructions to both approaches, the area which receives the lowest numerical rating is ranked No. 1. The area with the second lowest numerical rating is ranked No. 2. The area ranked No. 1 is more acceptable for ORRV use than the area ranked No. 2. To make evaluations comparable, the same rating approach should be used for each area being evaluated. When choosing a site for ORRV use, more consideration should be given to those areas ranked No. 1 or 2, because, from a biological point of view, they are the most acceptable for 4WD vehicle use. If possible, the use area should be the one ranked No. 1. This will help minimize damage to the biological resources of the installation as required by AR 210-9 and AR 200-2.

Consideration of Other Environmental Factors

During the site visit by the biologist and other surveyors, special attention should be paid to identifying any other significant environmental or safety factor which could adversely affect, or be affected by, 4WD vehicle use. These factors must be considered during the site selection process and should be addressed in the environmental assessment for area or trail development.

7 HOW TO ESTABLISH A 4WD VEHICLE AREA OR TRAIL

Site Selection

One of several goals of AR 210-9 is to have ORRV operators see designated ORRV-use areas as better than the undesignated areas they have been using without authorization. If this goal cannot be met, then diffuse, unregulated use will create environmental and safety problems. Increased levels of enforcement could theoretically confine ORRV use to a designated area, but the program would then be perceived as punitive, rather than constructive.

Many factors -- e.g., steep slopes and water crossings -- presented in this report as restrictions on the development of areas for 4WD vehicle use will be desired by at least some users. In general, terrain and vegetation variety is an absolute requirement for all users. Therefore, areas where 4WD vehicles may be operated may include some "restricted" terrain or other environmental feature. However, trail development should be such that trails meet most, if not all, exclusionary criteria discussed in Chapters 2 through 7. Site selection should be approached from the point of view of trying to provide an area that will be used voluntarily by most vehicle operators, rather than of trying to find some out-of-the-way place to "stick" an unwanted activity.

Alternative Selection

It is recommended that at least two to three alternative sites or trail corridors be selected which meet the criteria discussed in this report. The maximum acreage allowed for development is open to judgment, but it appears that no more than 100 to 150 ha may be safely maintained and monitored by most installations. Sites or corridors which have some sort of existing trail system should receive first consideration.

It must be remembered that ORRV-use areas may eventually have to support sanitary facilities, safe parking areas, resting areas, and possibly picnic areas. (TM 5-803-12 gives guidance for such developments.)[11] Access near installation entrances should be considered, since travel to remote areas will cause difficult or congested public travel routes within the installation.

Public Involvement

The wording of AR 210-9 leaves no doubt that any ORRV-use area should be established only in response to an expressed need. In practice, extensive unauthorized use may inform the Army planner that such need exists. The initial demand may come from off-installation organizations seeking a place to operate their vehicles. This is specifically anticipated by the regulation, and is permissible. These organizations, therefore, become one segment of the public from which ideas must be solicited before the ORRV-use area is finally

[11] Planning and Design of Outdoor Recreation Facilities, TM 5-803-12 (DA, 1 October 1975).

established. However, the concept of public participation is that all identifiable groups and persons, not just known ORRV proponents, should have an opportunity to comment during the process of selecting an ORRV-use area.

Appropriate, informal workshops and meetings should be held at least twice: first when initial plans and use criteria are being established, and again when candidate sites have been selected. These meetings are not hearings: they are intended to allow constructive observations from the public before any firm decisions have been made. A pamphlet describing public involvement as it applies to Corps of Engineers Civil Works actions provides guidance in obtaining public participation.[12] Further guidance relating to the concept of public involvement as it applies to water resources planning, including associated ORRV development, may be found in Engineering Regulation (ER) 1105-2-800.[13] Any appropriate source on public participation will be of some use. It is stressed that an area which fails to meet the needs of the potential users will be a failure. Once information from users and the public sector has been obtained, a use area can be chosen from the alternative sites.

Environmental Assessment

Before areas or trails are opened to vehicles, an environmental assessment or statement must be prepared. This is always required, because of the controversial nature of ORRV operation. Much of the information obtained from the evaluation procedures described here can be used in preparing these documents.

Trail Development

Until detailed criteria are established, the following brief outline of development suggestions can be used. Users can also help develop trails. It is emphasized that trail development should insure that the safety of vehicle operators is not compromised. User participation and public involvement will help identify potential safety hazards. Regular inspection of trails by qualified safety personnel is also recommended.

Length

Total trail length will vary depending on available acreage, the length of any existing trail system, and trail system design. If possible, a range of trail lengths should be offered to provide opportunities for both short and long trips. It is recommended that the minimum length be at least 6.4 km.

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[12] James R. Hanchey, Public Involvement in the Corps of Engineers' Planning Process, U. S. Army Engineer Institute for Water Resources (IWR) Research Report 75-R4 (IWR, October 1975).

[13] Planning -- Public Involvement: General Policies, Engineering Regulation (ER) 1105-2-800 (DA, OCE, 2 April 1974).

Width

All trails should have a cleared surface of not less than 1.8 m and no more than 3 m (for one-way traffic) and not less than 3.75 m nor more than 5 m (for two-way traffic). Natural obstructions such as rocks and trees can be used to prevent uncontrolled widening. However, location and/or placement of these barriers should be evaluated so that artificial safety hazards are not created. Trail width through turns should be larger than that on straight-aways so turns can be executed safely.

Slope

Portions of trails can climb slopes of up to 30 percent, but a maximum of 15 to 20 percent is recommended. For safety reasons, trails normally should not traverse slopes laterally. If it is necessary to traverse a slope, the trail should be cut and filled to provide a level surface for operation. Precautionary erosion control measures should be used. Army TMs 5-630 and 5-822-4 can provide initial guidance on possible erosion control measures.[14]

Surfaces

Natural soil will be the most commonly used surface material. If improvement is necessary, the best material is crushed or broken rock ranging in size from 10 to 40 mm. Gravel and rock should be incorporated into the natural surface. Bumps can be used along the trail to control vehicle speed. Trail segments which pass through wet areas may have to be built up with timber or be plank corduroy roadways.

Clearances

Trees, brush, fences, and other obstacles along the trail should be removed to provide clearance. A lateral cleared distance of 0.3 m from the edge of the defined trail is necessary; vertical clearance should be at least 2.5 m, but 3 m is recommended. Clearance should also be provided for sight along the trail, particularly on trails with two-way traffic.

Turns

Many varied turns with few long, straight runs are suggested. No single, straight section should exceed 100 m. Turn radii should be variable, with many turns of both more and less than 90 degrees. Natural obstructions should be used to prevent shortcutting. However, these barriers should not be a safety hazard. Steep-banked curves are to be avoided because they may encourage high speed and unwarranted operator confidence.

[14] Repairs and Utilities: Ground Maintenance and Land Management, TM 5-630 (DA, 4 December 1967); and Soil Stabilization for Roads and Streets, TM 5-822-4 (DA, 13 June 1969).

Water Hazards

If trails cross natural perennial streams, reinforced-surface fords, culverts, or bridges should be built. At least one novice trail which is free of water features should be planned. Highly developed and heavily used areas may include one or more artificially maintained water features, preferably supplied by artificially channelled runoff water. Water hazards should be well signed, and provisions should be made for suitable places to attach and anchor winch lines.

Vistas

If possible, there should be scenic vistas or rest areas along the trails. These will encourage users to stay on the trails.

Turnouts and Spurs

Trails should have turnouts and spurs so users can easily reach scenic vistas and rest areas.

Signing

Trails should be properly signed with regulatory, caution, trail marker, and informational signs. As a general rule, trail signs should, where applicable, follow Federal and State requirements for roads and roadways.

Operating Conditions

The installation commanding officer has authority, through AR 210-9, to allow a wide variety of activities at his or her discretion. In the absence of requirements to the contrary, it is recommended that the following minimum operating criteria initially be adopted.

License and Inspection

All vehicles operated by military personnel and/or their dependents shall be inspected by the Provost Marshal for compliance with all applicable safety regulations. No noncomplying vehicle will be allowed to use the ORRV area. All vehicles will be licensed for street operations, and will be inspected as necessary to meet State and local requirements. No unlicensed vehicles may be operated on the installation. All operators shall be licensed vehicle operators under the requirements of the State, or of their State of residence. No unlicensed operators will be allowed to operate a vehicle on the installation, regardless of whether or not certain types of unlicensed vehicle operation are permitted under State law.

Equipment

The following should be minimum equipment requirements for all recreational 4WD vehicles operated on the installation.

Roll Bar. All vehicles shall be equipped with a suitable roll bar. The roll bar shall be permanently attached to the vehicle. If a vehicle is

equipped with a factory-installed roll bar, it shall not be modified unless such modification is designed to improve the strength of the bar.

Seat Belts. All vehicles shall be equipped with seatbelts for the driver and any passengers. These belts should be used.

Muffler. All vehicles shall be equipped with a factory-equivalent muffler in good working condition.

Lights. All vehicles shall be equipped with functional headlights and taillights.

Passengers

Vehicles may carry passengers, provided that the number of passengers does not exceed the recommended industry capacity for the particular vehicle or Federal and State capacity requirements. In addition, vehicles shall carry no more passengers than there are functional seatbelts.

Direction of Traffic

All trails are to be clearly and conspicuously posted for either one- or two-way traffic and are to conform to the appropriate width recommendations for one- or two-way traffic. All traffic must use trails, and no general use of off-trail lands is permitted. A cleared area without trails and restricted to beginners may be provided.

Hours of Operation

At the commanding officer's discretion, vehicles may be allowed to operate after sunset, but it is recommended that operation not be permitted between 2300 and 0700 hours. All vehicles operated after dark must have functioning headlights and taillights and these lights must be used. If nighttime operation is not allowed, it is recommended that no vehicle be allowed to use the trail between 15 minutes after sunset and 15 minutes before sunrise, and that no operation be allowed between 2300 and 0700 hours, regardless of the time of sunrise and sunset. This operating condition should be imposed to avoid disturbing nonparticipants during normal sleeping hours.

Roadway Operation

It is recommended that recreational use of 4WD vehicles not be allowed on roadways normally used by other vehicles unless these roadways are closed to other traffic. If recreational vehicles must cross roadways, they should only be allowed to cross perpendicular to the roadway and after a complete stop.

Rules of the Road

It is recommended that recreational 4WD vehicles be operated according to all applicable rules and regulations for road or highway travel, as specified by installation, Federal, and State requirements. These and all operation conditions above should be adequately publicized and posted.

Supervision and Violations

To insure that operating regulations are followed, and to restrict use to designated trails and areas, it is recommended that there be supervision or patrol of the vehicle-use areas during periods of peak use. Organized recreational activities involving ORRVs are within the scope of the Outdoor Recreation Program, and supervision or patrol may be by Recreation Services personnel or by the Military Police, at the commanding officer's discretion. Violations of the conditions listed above and other posted operating regulations are to be treated as traffic violations. Citations may be issued upon the complaint of a trail or area supervisor or other officer, or by any installation enforcement person authorized to issue other vehicle and traffic citations.

Maintenance and Monitoring

Once areas and trails have been established, it will be necessary to provide appropriate trail maintenance and to monitor environmental effects.

Trail Maintenance

Periodic checks of areas and trails should be made to identify any maintenance problems. The most common problem will be erosion. Erosion control and soil management guidance can be found in many of the Army technical manuals listed in the bibliography to this report (Appendix C).

Monitoring Environmental Effects

AR 210-9, paragraph 6f, provides for the development of appropriate procedures to monitor the effects of ORRV use. Once an ORRV area has been established, use and changes in use intensity can significantly impact the area. Appendix D outlines a method of monitoring this impact. The method was adapted from Appendix D of ER 1130-2-405.[15] It is emphasized that the method is not intended to take the place of a disciplined scientific study, but is a limited method designed to monitor effects while taking into consideration budgetary constraints and personnel ceilings. This monitoring plan is very similar to those established by other Federal agencies with similar constraints.

A comparison of all data records collected over 5 years will help to determine the environmental effects of ORRV use. However, at this time, only professional judgment can be used to determine if impacts are significant and if changes in installation policy concerning ORRV use in a specific area should be implemented. This judgment should be solicited from professionals with expertise in various environmental disciplines, particularly biology, earth science, and soils.

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[15] Project Operation: Use of Off-Road Vehicles on Civil Works Projects, ER 1130-2-405 (DA, OCE, 17 January 1974).

8 CONCLUSION

This report has described how to use the CERL-developed method for evaluating land for use by off-road recreational 4WD vehicles. This method considers incompatible land uses, soil characteristics, noise impact, and biological suitability of candidate areas. User demand and participation, environmental assessment and documentation, and supervision needed to mitigate environmental impact were discussed. The method can be used to choose appropriate sites for recreational 4WD use on installation lands, establish trails and operating conditions, and perform environmental monitoring.

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APPENDIX A:

SELECTED, PRECALCULATED DNNAS FOR 4WD VEHICLE USE

This appendix lists several precalculated DNNAs for use in evaluating areas for possible use by recreational 4WD vehicles. DNNAs are distances that a 4WD vehicle trail would have to be from noise-sensitive land uses in order not to exceed recommended maximum acceptable noise-level requirements. Table A1 lists the DNNAs. To find an appropriate DNNA on Table A1, it is necessary to determine:

1. The Leq of the land use for which a buffer zone is needed or for which use limits must be determined.

2. The average daily use in numbers of 4WD vehicles (projected demand).

3. The average sound level (to the nearest even-number dBA) which is generated by these vehicles.

This information is obtained as described in Chapter 3 of this report.

Once these use parameters are known, the DNNAs for many noise-sensitive land uses can easily be found. Figure A1 shows how to use Table A1. The example in Figure A1 assumes an Leq of 70 dBA and a projected average daily use of 15 4WD vehicles generating an average sound level of 72 dBA. The DNNA is 132 m.

Table A1 can also be used to establish limits on the use of a potential 4WD vehicle trail. Using the example shown in Figure A1, assume that a proposed trail is located 132 m from a playground or active sport recreational area (Leq is 70 dBA in Table 1 of the main text). Also, the 4WD vehicles expected to use the trail generate an average sound level of 72 dBA. Therefore, the average daily use of the proposed trail must be limited to 15 vehicles to insure that maximum acceptable sound levels are not exceeded.

Table A1

The Distance Necessary for Noise Attenuation for Establishment of 4WD Use Areas (Distance in Meters)

Leq for Land Use (dBA)	Estimated Number of 4WD Vehicles Using the Area									Average Sound Level for 4WD Vehicles Using the Area (dBA at 15.24 m)
	5	10	15	20	25	30	40	50	60	
65	100	100	100	100	100	100	100	108	118	60
70	100	100	100	100	100	100	100	100	100	
75	100	100	100	100	100	100	100	100	100	
80	100	100	100	100	100	100	100	100	100	
65	100	100	100	100	100	105	121	136	149	62
70	100	100	100	100	100	100	100	100	100	
75	100	100	100	100	100	100	100	100	100	
80	100	100	100	100	100	100	100	100	100	
65	100	100	100	108	121	132	153	171	187	64
70	100	100	100	100	100	100	100	100	105	
75	100	100	100	100	100	100	100	100	100	
80	100	100	100	100	100	100	100	100	100	
65	100	100	118	136	152	167	192	215	236	66
70	100	100	100	100	100	100	108	121	133	
75	100	100	100	100	100	100	100	100	100	
80	100	100	100	100	100	100	100	100	100	
65	100	121	148	171	192	210	242	271	297	68
70	100	100	100	100	108	118	136	152	167	
75	100	100	100	100	100	100	100	100	100	
80	100	100	100	100	100	100	100	100	100	
65	108	152	187	216	241	264	305	341	373	70
70	100	100	105	121	136	149	172	192	210	
75	100	100	100	100	100	100	100	108	118	
80	100	100	100	100	100	100	100	100	100	

Table A1 (Cont'd)

Leq for Land Use (dBA)	Estimated Number of 4WD Vehicles Using the Area									Average Sound Level for 4WD Vehicles Using the Area (dBA at 15.24 m)
	5	10	15	20	25	30	40	50	60	
65	136	192	235	271	303	332	384	429	470	72
70	100	108	132	153	171	187	216	241	264	
75	100	100	100	100	100	105	121	136	149	
80	100	100	100	100	100	100	100	100	100	
65	100	242	296	342	382	419	483	540	592	74
70	100	136	166	192	215	235	272	304	333	
75	100	100	100	108	121	132	153	171	187	
80	100	100	100	100	100	100	100	100	105	
65	215	304	373	430	481	527	608	680	745	76
70	121	171	210	242	270	296	342	383	419	
75	100	100	118	136	152	167	192	215	236	
80	100	100	100	100	100	100	108	121	133	
65	271	383	469	542	605	663	766	856	938	78
70	152	215	264	305	341	373	431	482	527	
75	100	121	148	171	192	210	242	271	297	
80	100	100	100	100	108	118	136	152	167	
65	341	482	590	682	762	835	964	1078	1181	80
70	192	271	332	383	429	470	542	606	664	
75	108	152	187	216	241	264	305	341	373	
80	100	100	105	121	136	149	172	192	210	
65	429	607	743	858	960	1051	1214	1357	1487	82
70	241	341	418	483	540	591	683	763	836	
75	136	192	235	271	303	332	384	429	470	
80	100	108	132	153	171	187	216	241	264	

Table A1 (Cont'd)

Leq for Land Use (dBA)	Estimated Number of 4WD Vehicles Using the Area									Average Sound Level for 4WD Vehicles Using the Area (dBA at 15.24 m)
	5	10	15	20	25	30	40	50	60	
65	540	764	936	1081	1208	1323	1528	1704	1871	84
70	304	430	526	608	679	744	859	961	1052	
75	171	242	296	342	382	419	483	540	592	
80	100	136	166	192	215	235	272	304	333	
65	680	962	1178	1360	1521	1666	1924	2151	2356	86
70	382	541	662	765	855	937	1082	1209	1325	
75	215	304	373	430	481	527	608	680	745	
80	121	171	210	242	270	296	342	383	419	
65	856	1211	1483	1712	1915	2097	2422	2708	2966	88
70	481	681	834	963	1077	1179	1362	1523	1668	
75	271	383	469	542	605	663	766	856	938	
80	152	215	264	305	341	373	431	482	527	
65	1078	1524	1867	2156	2410	2640	3048	3409	3734	90
70	606	857	1050	1212	1355	1485	1715	1917	2100	
75	341	482	590	682	762	835	964	1078	1181	
80	192	271	332	383	429	470	542	606	664	
65	1357	1929	2350	2714	3034	3324	3838	4291	4701	92
70	763	1079	1322	1526	1706	1869	2158	2413	2644	
75	429	607	743	858	960	1051	1214	1357	1487	
80	241	341	418	483	540	591	683	763	836	
65	1708	2416	2959	3417	3820	4185	4382	5402	5918	94
70	960	1359	1664	1921	2148	2353	2717	3038	3328	
75	540	764	936	1081	1208	1323	1528	1704	1871	
80	304	430	526	608	679	744	859	961	1052	

Table A1 (Cont'd)

Leq for Land Use (dBA)	Estimated Number of 4WD Vehicles Using the Area									Average Sound Level for 4WD Vehicles Using the Area (dBA at 15.24 m)
	5	10	15	20	25	30	40	50	60	
65	2150	3042	3725	4301	4809	5268	6083	6801	7450	96
70	1209	1710	2095	2419	2704	2963	3421	3825	4190	
75	680	962	11[illegible]	1360	1521	1666	1924	2151	2356	
80	382	541	662	765	855	937	1082	1209	1325	
65	2707	3829	4690	5415	6054	6632	7658	8562	9379	98
70	1522	2153	2637	3045	3405	3730	4306	4815	5274	
75	856	1211	1483	1712	1915	2097	2422	270[illegible]	2966	
80	481	681	834	963	1077	1179	1362	1523	1668	
65	3408	4821	5904	6817	7622	8349	9641	10779	11808	100
70	1916	2711	3320	3834	4286	4695	5422	6062	6640	
75	1078	1524	1867	2156	2410	2640	3048	3409	3734	
80	606	857	1050	1212	1355	1485	1715	1917	2100	

Estimated Number of 4WD Vehicles Using the Area

Leq for Land Use (dBA)	5	10	15	20	25	30	40	50	60	Average Sound Level for 4WD Vehicles Using the Area (dBA at 15.24 m)
65	136	192	235	271	303	332	384	429	470	72
70	100	108	132	153	171	187	216	241	264	
75	100	100	100	100	100	105	121	136	149	
80	100	100	100	100	100	100	100	100	100	
65	171	242	296	342	382	419	483	540	592	74
70	100	136	166	192	215	235	272	304	333	
75	100	100	100	108	121	132	153	171	187	
80	100	100	100	100	100	100	100	100	105	
65	215	304	373	430	481	527	608	680	745	76
70	121	171	210	242	270	296	342	383	419	
75	100	100	118	136	152	167	192	215	236	
80	100	100	100	100	100	100	108	121	133	
65	271	383	469	542	605	663	766	856	938	78
70	152	215	264	305	341	373	431	482	527	
75	100	121	148	171	192	210	242	271	297	
80	100	100	100	100	108	118	136	152	167	
65	341	482	590	682	762	835	964	1078	1181	80
70	192	271	332	383	429	470	542	606	664	
75	108	152	187	216	241	264	305	341	373	
80	100	100	105	121	136	149	172	192	210	
65	429	607	743	858	960	1051	1214	1357	1487	82
70	241	341	418	483	540	591	683	763	836	
75	136	192	235	271	303	332	384	429	470	
80	100	108	132	153	171	187	216	241	264	

Figure A1. Example of finding the DNNA of an area using Table A1.

APPENDIX B:

BIOLOGICAL RATING FORM FOR ORRV-USE POTENTIAL

Figure B1 of this appendix is a blank copy of the biological rating form for evaluating areas for ORRV use. This form can be reproduced and used as described in Chapter 6.

Area _____

Rating _____ Rank _____

Biological Limitation _____

_____

Biological Resources	Relative Value	Categorical Value	Susceptibility to ORRV Damage	Categorical Susceptibility	Combined Resource Value	Notes
Ground Cover						
Trees or Dominant Vegetation						
Terrestrial Game Animals						
Terrestrial Nongame Animals						
Fish						
Pest species						
Other						
Total Area Value {			Total Combined Resource Value {			

Figure B1. Biological rating form for ORRV-use potential.

APPENDIX C:

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APPENDIX D:

MONITORING THE ENVIRONMENTAL
EFFECTS OF 4WD VEHICLE USE

AR 210-9 requires commanders of Army installations and activities to establish appropriate procedures to monitor the effects of ORRV use on their installations. This monitoring is to be the basis for changes in installation policy concerning ORRV use. Table D1 outlines a method of monitoring the environmental effects of ORRV use.

Table D1

Method of Monitoring the Environmental
Effects of ORRV Use

1. Estimate use of the area or trails by ORRV users.

2. Determine impact of ORRV use on vegetation and soil.

a. Map existing trails in designated ORRV area.
b. Record mileage and average width of existing trails.
c. Rate existing trails according to light, medium, or heavy use.
d. Select random sample plots on and along existing trails which are representative of a variety of terrain, vegetative, and soil conditions.

(1) Photograph sample plots.
(2) Record trail width and rut depths at selected intervals. Also record other notable features, such as potholes, along entire trail length.
(3) Inventory the vegetative community within the sample plots. This inventory should include species composition, size of woody vegetation, and number of dead stems greater than 20 mm in diameter.
(4) Record general condition of vegetation in sample plot. Note damaged tree bark and roots, and condition of herbaceous vegetation.

e. Record initially, and at intervals of 1, 3, and 5 years, those items included in d, above.
f. Define control plots near test plots to determine impact with and without ORRV use. Control plots should be about 18 m from the trail center. Record all appropriate information on control plots for comparison with sample plots.
g. Permanently, but inconspicuously, mark all control and test plots so that photographs and data collection can be done in the same area in subsequent years.
h. Determine the following from test sections:

(1) Impact on young vegetative growth.
(2) Impact on larger trees and shrubs (compaction, direct damage, root exposure).
(3) Impact on soil (erosion, compaction, lateral movement).

Table D1 (Cont'd)

(4) Trail width and depth variation from year to year.
(5) Extent of impact on either side of trail. Changes in trail such as expansion of potholes and ruts.
(6) Comparison of ORRV impact on test plots with control plots.

i. Annually spot-check vulnerable areas such as steep slopes, creek banks, and lake shoreline. Record any noticeable increases in erosion or other damage.

3. Determine ORRV impact on wildlife.

a. Record track counts of big game animals such as deer, antelope, and elk in ORRV area and compare to those outside ORRV area.
b. Count game birds and nongame birds by their songs.
c. If hunting is permitted, compare wildlife harvest in ORRV area to that of other areas on the installation.
d. Record sightings of game and nongame species in and outside ORRV-use area.

4. Determine ORRV impact on other activities.

a. Survey type and amount of recreation and other use in areas adjacent to designated ORRV areas.
b. Record as accurately as possible the attitudes of persons who are surveyed.
c. Record distance between area where survey is made and the ORRV area.

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